

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner  
 US Department of Commerce  
 United States Patent and Trademark  
 Office, PCT  
 2011 South Clark Place Room  
 CP2/5C24  
 Arlington, VA 22202  
 ETATS-UNIS D'AMERIQUE  
 in its capacity as elected Office

Date of mailing (day/month/year) 02 May 2001 (02.05.01)	
International application No. PCT/GB00/02873	Applicant's or agent's file reference ICOT/P23197PC
International filing date (day/month/year) 25 July 2000 (25.07.00)	Priority date (day/month/year) 27 July 1999 (27.07.99)
Applicant COLLINGE, John et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

27 February 2001 (27.02.01)

☐ in a notice effecting later election filed with the International Bureau on:
2. The election ☒ was
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer  S. Mafla Telephone No.: (41-22) 338.83.38
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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/10104

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	TELLING, G.C. et al., Transmission of Creutzfeldt-Jakob disease from humans to transgenic mice expressing chimeric human-mouse prion protein. Proceedings of the National Academy of Sciences, USA. October 1994, Vol. 91, pages 9936-9940, see entire document.	1, 2, and 7
Y	COHEN, F.E. et al., Structural Clues to Prion Replication. Science. 22 April 1994, Vol. 264, pages 530 and 531, see entire document.	1, 2, and 7.
Y,P	YEHIELY, F. et al., Identification of candidate proteins binding to prion proteins. Neurobiology of Disease. 1997, Vol. 3, No. 4, pages 339-355, see entire document.	1, 2, and 7

Form PCT/ISA/210 (continuation of second sheet)(July 1992)\*

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/10104

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1, 2, and 7

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.  
☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1))(July 1992)\*



# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US98/10104

## B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

Databases: Agricola; Aidslines; Anabstr; Aquasci; Biobusiness; Biosis; biotechabs; Biotechds; CABA; Cancerlit; Caplus; CEABA; CEN; CIN; CJACS; Confsci; CROPB; CROPU; DGENE; DISSABS; DRUGB; Druglaunch; DRUGNL; DRUGU; EMBAL; EMBASE; FSTA; GENBANK; Healsafe; IFIPAT; JICST-EPLUS; KOSMET; LIFESCI; MEDLINE; NIOSHTIC; NTIS; OCEAN; PHAR; PHIC; PHIN; PROMT; SciSearch; Toxline; Toxlit; USPATFULL; APS; WPIDS

Search Terms: prion?; protein?; modulat?; factor?; prusiner?/au; cohen?/au; protein x

## BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

- Group I, claim(s) 1, 2, and 7, drawn to prion protein modulator factors (PPMF).
- Group II, claim(s) 3 and 4, drawn to mimetic pharmacophores of PPMF.
- Group III, claim(s) 5 and 6, drawn to mutant PrP (prion) genes.
- Group IV, claim(s) 8, drawn to antibodies to PPMF/PrP binding sites.
- Group V, claim(s) 9, drawn to transgenic animals harboring mutant PrP genes.
- Group VI, claim 10, drawn to *in vitro* methods of assaying for compounds that inhibits PrP<sup>Sc</sup> formation.

The inventions listed as Groups I-VI do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The technical feature of the invention of Group I is drawn to PPMF proteins which are defined as proteins that bind to PrP<sup>C</sup> and facilitate a conformational change of PrP<sup>C</sup> to PrP<sup>Sc</sup> (see Description at page 4, lines 10 and 11). However, the prior art as exemplified by Cohen et al., (Science. Vol. 264. 22 April 1994), teaches that exogenous prions which fall within the definition of PPMF proteins as instantly claimed, facilitate the a conformational change of PrP<sup>C</sup> to PrP<sup>Sc</sup> (see e.g. Figure 1). Therefore, the claimed PPMF proteins are either taught or obvious in view of the prior art and does not therefore represent a special technical feature within the meaning of PCT Rule 13.2.

The inventions of Groups I-V are distinct one from the other, because each of these inventions are drawn to materially different compounds or compositions that bear no requisite structural or functional relationship. For example, the invention of group I is drawn to PPMF proteins; the invention of group II to mimetics of such which are not required to be proteins; the invention of group III to recombinant genes (nucleic acids); the invention of group IV to antibody molecules; and the invention of group V to transgenic animals. Each of these compounds and compositions have disparate structures and functions that are not necessarily concordant and therefore the several groups of inventions lack any special technical feature within the meaning of PCT Rule 13.2 so as to form a single inventive concept.

The inventions of each of Groups I-V are distinct from the invention of group VI because the latter invention is drawn to *in vitro* assays that do not *per se* require the use of any of the compounds or compositions of the former Groups of inventions. Therefore, no special technical feature within the meaning of PCT Rule 13.2 links the claimed compounds/compositions with the claimed assay methods.

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# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>ICOT / P23197PC</b>	<b>FOR FURTHER ACTION</b> <small>see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, Item 5 below.</small>	
International application No. <b>PCT/GB 00/02873</b>	International filing date (day/month/year) <b>25/07/2000</b>	(Earliest) Priority Date (day/month/year) <b>27/07/1999</b>
Applicant  <b>IMPERIAL COLLEGE INNOVATIONS LIMITED</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 6 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

- a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☒ furnished subsequently to this Authority in written form.

☒ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☒ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☒ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of invention is lacking (see Box II).

4. With regard to the title,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

FRAGMENTS OF CELLULAR PRION PROTEIN AND METHODS USEFUL IN THE DIAGNOSIS AND TREATMENT OF PRION DISEASES

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the drawings to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

2  
☐ None of the figures.

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 00/02873

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 C07K14/47 C07K16/18 G01N33/68

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 C07K G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
EPO-Internal, BIOSIS, WPI Data, PAJ, CHEM ABS Data, STRAND

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 55132 A (UNIV CALIFORNIA) 10 December 1998 (1998-12-10)  claims; figure 3; examples	3-7, 9, 12, 13, 16-18, 23, 24
X	WO 98 37210 A (ZUERICH ERZIEHUNGSDIREKTION ;KORTH CARSTEN (CH); OESCH BRUNO (CH);) 27 August 1998 (1998-08-27)  seq id no. 9 claims; examples  -/-	3-7, 9, 12, 13, 16-18, 23, 24

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*Z\* document member of the same patent family

Date of the actual completion of the international search

24 January 2001

Date of mailing of the international search report

05/02/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Fuhr, C

**THIS IS A PATENT (USPTO)**

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/02873

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SCOTT MICHAEL R ET AL: "Identification of a prion protein epitope modulating transmission of bovine spongiform encephalopathy prions to transgenic mice." PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES, vol. 94, no. 26, 23 December 1997 (1997-12-23), pages 14279-14284, XP002158407 Dec. 23, 1997 ISSN: 0027-8424 page 14282, right-hand column, paragraph 5 -page 14283, left-hand column, paragraph 1	3-7
P,X	DATABASE BIOSIS 'Online! BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US; August 1999 (1999-08) HOSSZU LASZLO L P ET AL: "Structural mobility of the human prion protein probed by backbone hydrogen exchange." Database accession no. PREV199900385677 XP002158408 abstract & NATURE STRUCTURAL BIOLOGY, vol. 6, no. 8, August 1999 (1999-08), pages 740-743, ISSN: 1072-8368	3-25

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## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

## Continuation of Box I.1

As far as claim(s) 23 and 24 are directed to a diagnostic method practised on the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

As far as claim 23 is directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

## Continuation of Box I.2

Claims Nos.: 1,2,8,11,14,26-29

Present claims 1, 2 and 27 relate to a compound defined (inter alia) by reference to the following parameter(s): it exhibits stability when measured by hydrogen/deuterium amide exchange at pH 5.5.

The use of these parameters in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameters the applicant has chosen to employ with what is set out in the prior art. The lack of clarity is such as to render a meaningful complete search impossible. Consequently, the search has been restricted to peptides consisting of all or a fragment or variant of an amino acid sequence from residue number 176 to 221 or the prpc according to figure 5 (including dependent claims thereof and including antibodies against peptides and methods and uses thereof)

Present claims 8, 11, 14, 26 and 28-29 relate to a product defined by reference to a desirable characteristic or property, namely the ability to bind preferably to cellular prion protein than to prion protein sc.

The claims cover all products having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT for only a very limited number of such products. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the product by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible. Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the products which bind to peptide sequences derived from the region between positions 176 to 221 of the cellular prion protein.

Present claim 30 was search within the scope of other claims searched.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant

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**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/GB 00/02873

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
see FURTHER INFORMATION sheet PCT/ISA/210
2. ☒ Claims Nos.: 1,2,8,11,14,26-29  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/02873

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
W0 9855132	A	10-12-1998	US	5962669 A	05-10-1999
			AU	7796798 A	21-12-1998
			EP	0986396 A	22-03-2000
W0 9837210	A	27-08-1998	EP	0861900 A	02-09-1998
			AU	6498698 A	09-09-1998
			EP	1007700 A	14-06-2000

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## PCT

## REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date.

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference  
(if desired) (12 characters maximum) ICOT / P23197PC

<b>Box No. I</b>	<b>TITLE OF INVENTION</b> BIOLOGICAL MATERIALS AND METHODS USEFUL IN THE DIAGNOSIS AND TREATMENT OF DISEASES	
<b>Box No. II</b>	<b>APPLICANT</b>	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) Imperial College Innovations Limited Sherfield Building Imperial College London SW7 2AZ United Kingdom		<input type="checkbox"/> This person is also inventor.  Telephone No.  Facsimile No.  Teleprinter No.
State (that is, country) of nationality: GB		State (that is, country) of residence: GB
This person is applicant <input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
<b>Box No. III</b>	<b>FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)</b>	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) COLLINGE, John MRC Prion Unit Department of Neurogenetics Imperial College School of Medicine at St Mary's Norfolk Place London W2 1PG United Kingdom		This person is:  <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only (if this check-box is marked, do not fill in below.)
State (that is, country) of nationality: GB		State (that is, country) of residence: GB
This person is applicant <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box		
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet.		
<b>Box No. IV</b>	<b>AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE</b>	
The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: <input checked="" type="checkbox"/> agent <input type="checkbox"/> common representative		
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.) Thomas, Philip J D Eric Potter Clarkson Park View House 58 The Ropewalk Nottingham. NG1 5DD GB		Telephone No. (0115) 9552211  Facsimile No. (0115) 9552201  Teleprinter No. 37540 Potter G
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.		

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Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request.</i>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>CLARKE, Anthony Russell MRC Prion Unit Imperial College School of Medicine at St Mary's Norfolk Place London W2 1PG United Kingdom</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (if this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: GB	State (that is, country) of residence: GB
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated states <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>WALTHO, Jonathan Peter 14 Rock Cottages Cressbrook Nr Buxton Derbyshire SK17 8SY United Kingdom</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (if this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: GB	State (that is, country) of residence: GB
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated states <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>JACKSON, Graham Stuart MRC Prion Unit Imperial College School of Medicine at St Mary's Norfolk Place London W2 1PG United Kingdom</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (if this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: GB	State (that is, country) of residence: GB
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated states <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p>Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</p> <p>HOSSZU, Laszlo Luis Pereira MRC Prion Unit Imperial College School of Medicine at St Mary's Norfolk Place London W2 1PG United Kingdom</p>	<p>This person is:</p> <p><input type="checkbox"/> applicant only</p> <p><input checked="" type="checkbox"/> applicant and inventor</p> <p><input type="checkbox"/> inventor only (if this check-box is marked, do not fill in below.)</p>
State (that is, country) of nationality: GB	State (that is, country) of residence: GB
<p>This person is applicant for the purposes of: <input type="checkbox"/> all designated states <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box</p>	
<p><input type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet.</p>	

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**Box No. V DESIGNATION OF STATES**

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):  
**Regional Patent**

- ☒ **AP** **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ **EA** **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ **EP** **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ **OA** **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

**National Patent** (if other kind of protection or treatment desired, specify on dotted line):

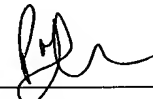
- |  |  |
|--|--|
| <input checked="" type="checkbox"/> AE United Arab Emirates                  | <input checked="" type="checkbox"/> LR Liberia                                   |
| <input checked="" type="checkbox"/> AL Albania                               | <input checked="" type="checkbox"/> LS Lesotho                                   |
| <input checked="" type="checkbox"/> AM Armenia                               | <input checked="" type="checkbox"/> LT Lithuania                                 |
| <input checked="" type="checkbox"/> AT Austria                               | <input checked="" type="checkbox"/> LU Luxembourg                                |
| <input checked="" type="checkbox"/> AU Australia                             | <input checked="" type="checkbox"/> LV Latvia                                    |
| <input checked="" type="checkbox"/> AZ Azerbaijan                            | <input checked="" type="checkbox"/> MA Morocco                                   |
| <input checked="" type="checkbox"/> BA Bosnia and Herzegovina                | <input checked="" type="checkbox"/> MD Republic of Moldova                       |
| <input checked="" type="checkbox"/> BB Barbados                              | <input checked="" type="checkbox"/> MG Madagascar                                |
| <input checked="" type="checkbox"/> BG Bulgaria                              | <input checked="" type="checkbox"/> MK The former Yugoslav Republic of Macedonia |
| <input checked="" type="checkbox"/> BR Brazil                                | <input checked="" type="checkbox"/> MN Mongolia                                  |
| <input checked="" type="checkbox"/> BY Belarus                               | <input checked="" type="checkbox"/> MW Malawi                                    |
| <input checked="" type="checkbox"/> CA Canada                                | <input checked="" type="checkbox"/> MX Mexico                                    |
| <input checked="" type="checkbox"/> CH and LI Switzerland and Liechtenstein  | <input checked="" type="checkbox"/> NO Norway                                    |
| <input checked="" type="checkbox"/> CN China                                 | <input checked="" type="checkbox"/> NZ New Zealand                               |
| <input checked="" type="checkbox"/> CR Costa Rica                            | <input checked="" type="checkbox"/> PL Poland                                    |
| <input checked="" type="checkbox"/> CU Cuba                                  | <input checked="" type="checkbox"/> PT Portugal                                  |
| <input checked="" type="checkbox"/> CZ Czech Republic                        | <input checked="" type="checkbox"/> RO Romania                                   |
| <input checked="" type="checkbox"/> DE Germany                               | <input checked="" type="checkbox"/> RU Russian Federation                        |
| <input checked="" type="checkbox"/> DK Denmark                               | <input checked="" type="checkbox"/> SD Sudan                                     |
| <input checked="" type="checkbox"/> DM Dominica                              | <input checked="" type="checkbox"/> SE Sweden                                    |
| <input checked="" type="checkbox"/> EE Estonia                               | <input checked="" type="checkbox"/> SG Singapore                                 |
| <input checked="" type="checkbox"/> ES Spain                                 | <input checked="" type="checkbox"/> SI Slovenia                                  |
| <input checked="" type="checkbox"/> FI Finland                               | <input checked="" type="checkbox"/> SK Slovakia                                  |
| <input checked="" type="checkbox"/> GB United Kingdom                        | <input checked="" type="checkbox"/> SL Sierra Leone                              |
| <input checked="" type="checkbox"/> GD Grenada                               | <input checked="" type="checkbox"/> TJ Tajikistan                                |
| <input checked="" type="checkbox"/> GE Georgia                               | <input checked="" type="checkbox"/> TM Turkmenistan                              |
| <input checked="" type="checkbox"/> GH Ghana                                 | <input checked="" type="checkbox"/> TR Turkey                                    |
| <input checked="" type="checkbox"/> GM Gambia                                | <input checked="" type="checkbox"/> TT Trinidad and Tobago                       |
| <input checked="" type="checkbox"/> HR Croatia                               | <input checked="" type="checkbox"/> TZ United Republic of Tanzania               |
| <input checked="" type="checkbox"/> HU Hungary                               | <input checked="" type="checkbox"/> UA Ukraine                                   |
| <input checked="" type="checkbox"/> ID Indonesia                             | <input checked="" type="checkbox"/> UG Uganda                                    |
| <input checked="" type="checkbox"/> IL Israel                                | <input checked="" type="checkbox"/> US United States of America                  |
| <input checked="" type="checkbox"/> IN India                                 | <input checked="" type="checkbox"/> UZ Uzbekistan                                |
| <input checked="" type="checkbox"/> IS Iceland                               | <input checked="" type="checkbox"/> VN Viet Nam                                  |
| <input checked="" type="checkbox"/> JP Japan                                 | <input checked="" type="checkbox"/> YU Yugoslavia                                |
| <input checked="" type="checkbox"/> KE Kenya                                 | <input checked="" type="checkbox"/> ZA South Africa                              |
| <input checked="" type="checkbox"/> KG Kyrgyzstan                            | <input checked="" type="checkbox"/> ZW Zimbabwe                                  |
| <input checked="" type="checkbox"/> KP Democratic People's Republic of Korea |  |
| <input checked="" type="checkbox"/> KR Republic of Korea                     |  |
| <input checked="" type="checkbox"/> KZ Kazakhstan                            |  |
| <input checked="" type="checkbox"/> LC Saint Lucia                           |  |
| <input checked="" type="checkbox"/> LK Sri Lanka                             |  |

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

- ☒ DZ Algeria ☒ BZ Belize  
☒ AG Antigua and Barbuda ☒ MZ Mozambique

**Precautionary Designation Statement:** In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

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<b>Box No. VI PRIORITY CLAIM</b>		<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box.		
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		National application: Country	regional application:* regional Office	international application: receiving Office
item (1) 27 July 1999 (27/07/1999)	9917491.4	GB		
item (2) 30 July 1999 (30/07/1999)	9917878.2	GB		
item (3)				
<input checked="" type="checkbox"/> The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): (1) (2)				
<i>* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.</i>				
<b>Box No. VII INTERNATIONAL SEARCHING AUTHORITY</b>				
Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):		Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):		
ISA /		Date (day/month/year)	Number	Country (or regional Office)
<b>Box No. VIII CHECK LIST; LANGUAGE OF FILING</b>				
This international application contains the following number of sheets:		This international application is accompanied by the item(s) marked below:		
request : 4		1. <input type="checkbox"/> fee calculation sheet		
description (excluding sequence listing part) : 55		2. <input type="checkbox"/> separate signed power of attorney		
claims : 5		3. <input checked="" type="checkbox"/> copy of general power of attorney; reference number, if any:		
abstract : 1		4. <input type="checkbox"/> statement explaining lack of signature		
drawings : 7		5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s):		
sequence listing part of description : 0		6. <input type="checkbox"/> translation of international application into (language):		
<b>Total number of sheets</b> : 72		7. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material		
		8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form		
		9. <input type="checkbox"/> other (specify):		
Figure of the drawings which should accompany the abstract: 2		Language of filing of the International application: English		
<b>Box No. IX SIGNATURE OF APPLICANT OR AGENT</b>				
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).				
 Philip J D Thomas				

For receiving Office use only	
1. Date of actual receipt of the purported international application: 3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application: 4. Date of timely receipt of the required corrections under PCT Article 11(2): 5. International Searching Authority (if two or more are competent): ISA /	2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received:
6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid.	
For International Bureau use only	
Date of receipt of the record copy by the International Bureau:	

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# PATENT COOPERATION TREATY

From the:  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

THOMAS, Philip JD.  
ERIC POTTER CLARKSON  
Park View House  
58 The Ropewalk  
Nottingham NG1 5DD  
GRANDE BRETAGNE

COMUS	PARTNER
NOTED	17 MAY 2001
OFFICE	
ACTIONED BY: <i>AW</i>	

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing  
(day/month/year) : 15.05.2001

Applicant's or agent's file reference  
ICOT/P23197PC

REPLY DUE : within 3 month(s)  
from the above date of mailing

International application No.  
PCT/GB00/02873

International filing date (day/month/year)  
25/07/2000

Priority date (day/month/year)  
27/07/1999

International Patent Classification (IPC) or both national classification and IPC  
C07K16/00

Applicant

IMPERIAL COLLEGE INNOVATIONS LIMITED

1. This written opinion is the first drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain document cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

**When?** See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

**How?** By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

**Also:** For an additional opportunity to submit amendments, see Rule 66.4.  
For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.  
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 27/11/2001.

Name and mailing address of the international preliminary examining authority:

 European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0 Tx: 523656 epmu d  
Fax: +49 89 2399 - 4465

Authorized officer / Examiner

Weijland, A

Formalities officer (incl. extension of time limits)

SIEDSMA, Y

Telephone No. +49 89 2399



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## WRITTEN OPINION

International application No. PCT/GB00/02873

### I. Basis of the opinion

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed"*):

#### Description, pages:

1-55 as originally filed

#### Claims, No.:

1-30 as originally filed

#### Drawings, sheets:

1/17-17/17 as originally filed

#### Sequence listing part of the description, pages:

Figure 5, as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☒ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

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## WRITTEN OPINION

International application No. PCT/GB00/02873

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

### III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been and will not be examined in respect of:

- ☐ the entire international application,
- ☒ claims Nos. 1,2,8,11,14,26-30,

because:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 30 are so unclear that no meaningful opinion could be formed (*specify*):  
see separate sheet
- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☒ no international search report has been established for the said claims Nos. 1,2,8,11,14,26-29.

2. A written opinion cannot be drawn due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

- ☐ the written form has not been furnished or does not comply with the standard.
- ☐ the computer readable form has not been furnished or does not comply with the standard.

### V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

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## WRITTEN OPINION

International application No. PCT/GB00/02873

- |                               |                                    |
|-------------------------------|------------------------------------|
| 1. Statement                  |                                    |
| Novelty (N)                   | Claims 6,9,12,13,15-17,20-23,25 No |
| Inventive step (IS)           | Claims 3-6,7,9,10,12,13,15-25 No   |
| Industrial applicability (IA) | Claims                             |

2. Citations and explanations  
see separate sheet

### VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:  
see separate sheet

### VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
see separate sheet

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**WRITTEN OPINION  
SEPARATE SHEET**

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International application No. PCT/GB00/02873

The following documents (D) are referred to in this opinion; the numbering will be adhered to the rest of the procedure:

- D1: WO 98 55132 A (UNIV CALIFORNIA) 10 December 1998 (1998-12-10)
- D2: WO 98 37210 A (ZUERICH ERZIEHUNGSDIREKTION ;KORTH CARSTEN (CH); OESCH BRUNO (CH);) 27 August 1998 (1998-08-27)
- D3: SCOTT MICHAEL R ET AL: 'Identification of a prion protein epitope modulating transmission of bovine spongiform encephalopathy prions to transgenic mice.' PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES, vol. 94, no. 26, 23 December 1997 (1997-12-23), pages 14279-14284, XP002158407 Dec. 23, 1997 ISSN: 0027-8424
- D4: DATABASE BIOSIS [Online] BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US; August 1999 (1999-08) HOSSZU LASZLO L P ET AL: 'Structural mobility of the human prion protein probed by backbone hydrogen exchange.' Database accession no. PREV199900385677 XP002158408 & NATURE STRUCTURAL BIOLOGY, vol. 6, no. 8, August 1999 (1999-08), pages 740-743, ISSN: 1072-8368

**SECTION III**

1. Claims 1,2,8,11,14 and 26-29 were not subject of the International search, consequently they will not be subject of International Examination.
2. Claim 30 is supposed to be not clear, since it contains no technical features that could be the subject of an International Examination.

**SECTION V**

3. Novelty (Article 33(2) PCT)
- 3.1 The subject matter of claims 6,9,12,13,15-17,20-23,25 is not novel.

Claims 12,15,16 and 17 are anticipated by D1. D1 (abstract; example 1) describes a prion Protein Modulator Factor (PPMF) that binds to the discontinuous epitope

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on PrP<sup>c</sup> comprising amino acid residues 172, 215 and 219. Antibodies are disclosed which bind on the binding interface of PPMF and PrP<sup>c</sup> that are useful in the treatment of the prion disease. Protease resistance ("detecting a cellular form of a prion protein", "detecting the non-cellular form of a prion protein" according to claims 16 and 17) was used to verify if conversion of PrP<sup>c</sup> to PrP<sup>Sc</sup> by binding of PPMF ("binding agent" according to claims 12,15,16 and 17) could be influenced by point mutations.

Claims 6,9,12,13,15-17, 20-23 and 25 are anticipated by D2. D2 (abstract; page 17, last paragraph, page 18, first paragraph; page 20, lines 12 to 21; page 33, third paragraph; claims 30 and 36) describes monoclonal antibodies useful in immunological assays to identify prions in tissues and body fluids. Mice are immunized with recombinant fragments of PrP<sup>c</sup> and the antibodies are used for therapeutic and preventive treatments of humans and animals. A hybridoma cell line was produced by administering to PrP<sup>0/0</sup> mice an immunizing amount of recombinant pure prion protein PrP ("A method of making an antibody", "A method of making a monoclonal antibody", "A method of making a binding agent", "antibody" according to present claims 6, 9, 12,13,15). The spleen is removed and fused with myeloma cells. An antibody, i.e. 15B3, is produced that binds only native disease-specific PrP<sup>Sc</sup> ("agent which binds the non-cellular form" according to present claim 17). Two other antibodies, i.e. 6H4 and 34C9 ("the antibody" according to present claim 17), bind to conserved or species specific regions respectively. To map the epitopes a peptide library ("sample" according to present claims 16 or 17) is used. A method for the prevention of prion disease is described by administering to a patient a monoclonal antibody which is specific for PrP<sup>c</sup> ("A method for use in the prevention of a prion related disease" according to present claims 23 and 20 to 22). A test kit is disclosed for the diagnosis of prion diseases comprising monoclonal antibodies ("A kit" according to present claim 25).

Claim 6 is anticipated by D3. D3 (page 14280, left column, second paragraph) describes an anti-rabbit polyclonal antibody raised against a synthetic peptide corresponding to residues 90-145 of PrP ("a method of making an antibody" according to present claim 6).

2.2 Claims 3-5,7,10,18,19,24 are not disclosed in the prior art documents.

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**3. Inventive Step (Article 33(3) PCT)**

Dependent claims 3-5,7,10,18,19,24 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, since :

the peptides of claims 3 to 5 are considered as non inventive selections of the whole amino acid sequence without resulting in any unexpected effect, whatsoever.

The antibodies of claims 7 and 10 would be obtained by the common tools present in the state of the art, without resulting in any unexpected effect whatsoever, see for example the screening procedure of D2 mentioned in Section 2.1 above.

The uses of claims 18 and 19 or the method of claim 24 are mere alternatives of respectively the use of an antibody (claims 18 and 19) or a method (claim 24) without encompassing any technical features that would lead to any unexpected effect whatsoever.

4. The priority of the present application is validly claimed. Therefore, D4 does not belong to the state of the art as defined in Rule 64.1 PCT.

**SECTION VII**

5. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D2 is not mentioned in the description, nor is this document identified therein.

**SECTION VIII**

6. The applicant attributes to the term "fragment or variant" in claims 1,3-5 a special meaning (see page 5, lines 15-22 and page 6, lines 15-18), which was not generally known in the technical field concerned at the relevant filing date and contravenes the requirement that the meaning needs to be clear from the wording

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**WRITTEN OPINION  
SEPARATE SHEET**

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International application No. PCT/GB00/02873

of the claim alone (the Guidelines C-III 4.2, Article 6 PCT).

7. It is not clear from the wording of claim 25, which technical features are specified in the kit and therefore the requirements of Article 6 PCT are not met.

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# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>ICOT/P23197PC</b>		<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. <b>PCT/GB00/02873</b>	International filing date (day/month/year) <b>25/07/2000</b>	Priority date (day/month/year) <b>27/07/1999</b>	
International Patent Classification (IPC) or national classification and IPC <b>C07K16/00</b>			
Applicant <b>IMPERIAL COLLEGE INNOVATIONS LIMITED</b>			
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 8 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 5 sheets.</p>			
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <li>I <input checked="" type="checkbox"/> Basis of the report</li> <li>II <input type="checkbox"/> Priority</li> <li>III <input checked="" type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</li> <li>IV <input type="checkbox"/> Lack of unity of invention</li> <li>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</li> <li>VI <input type="checkbox"/> Certain documents cited</li> <li>VII <input checked="" type="checkbox"/> Certain defects in the international application</li> <li>VIII <input checked="" type="checkbox"/> Certain observations on the international application</li> </ul>			
Date of submission of the demand <b>27/02/2001</b>		Date of completion of this report <b>24.10.2001</b>	
Name and mailing address of the International preliminary examining authority:  <b>European Patent Office</b> <b>D-80298 Munich</b> <b>Tel. +49 89 2399 - 0 Tx: 523656 eprnu d</b> <b>Fax: +49 89 2399 - 4465</b>		Authorized officer  <b>Weijland, A</b>  Telephone No. +49 89 2399 7490	



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**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/02873

**1. Basis of the report**

1. With regard to the elements of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17):*)
- Description, pages:**

1-55 as originally filed

**Claims, No.:**

1-28 as received on 21/08/2001 with letter of 15/08/2001

**Drawings, sheets:**

1/17-17/17 as originally filed

**Sequence listing part of the description, pages:**

Figure 5, as originally filed

1-38, filed with the letter of 25.10.2000

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☒ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☒ furnished subsequently to this Authority in written form.
- ☒ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☒ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

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**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/02873

- ☐ the description, pages:  
☐ the claims, Nos.:  
☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability**

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.  
☒ claims Nos. 6, 9, 12, 24-28.

because:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 28 are so unclear that no meaningful opinion could be formed (*specify*):  
**see separate sheet**
- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☒ no international search report has been established for the said claims Nos. 6,9,12, 24-27.

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

- ☐ the written form has not been furnished or does not comply with the standard.  
☐ the computer readable form has not been furnished or does not comply with the standard.

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/02873

**1. Statement**

Novelty (N)	Yes:	Claims	1-3,10,11,13,16,17,19,20,22
	No:	Claims	4,5,7,8,14,15,18,21,23
Inventive step (IS)	Yes:	Claims	1-3,10,11,13
	No:	Claims	4,5,7,8,14-23
Industrial applicability (IA)	Yes:	Claims	1-5,7,8,10,11,13-23
	No:	Claims	

**2. Citations and explanations**  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

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**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/02873

The following documents (D) are referred to in this report; the numbering will be adhered to the rest of the procedure:

- D1: WO 98 55132 A (UNIV CALIFORNIA) 10 December 1998 (1998-12-10)
- D2: WO 98 37210 A (ZUERICH ERZIEHUNGSDIREKTION ;KORTH CARSTEN (CH); OESCH BRUNO (CH);) 27 August 1998 (1998-08-27)
- D3: SCOTT MICHAEL R ET AL: 'Identification of a prion protein epitope modulating transmission of bovine spongiform encephalopathy prions to transgenic mice.' PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES, vol. 94, no. 26, 23 December 1997 (1997-12-23), pages 14279-14284, XP002158407 Dec. 23, 1997 ISSN: 0027-8424
- D4: DATABASE BIOSIS [Online] BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US; August 1999 (1999-08) HOSSZU LASZLO L P ET AL: 'Structural mobility of the human prion protein probed by backbone hydrogen exchange.' Database accession no. PREV199900385677 XP002158408 & NATURE STRUCTURAL BIOLOGY, vol. 6, no. 8, August 1999 (1999-08), pages 740-743, ISSN: 1072-8368

**SECTION III**

- 1. Claims 6,9,12, 24-27 were not subject of the International search, consequently they will not be subject of International Examination.
- 2. Claim 28 is supposed to be not clear, since it contains no technical features that could be the subject of an International Examination.

**SECTION V**

- 3. Novelty (Article 33(2) PCT)
- 3.1 The subject matter of claims 4,5,7,8,14, 15, 18, 21,23 is not novel.

Claims 4,5,7,8,14, 15, 18, 21 and 23 are anticipated by D2. D2 (abstract; page 17, last paragraph, page 18, first paragraph; page 20, lines 12 to 21; page 33, third

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International application No. PCT/GB00/02873

paragraph; claims 30 and 36) describes monoclonal antibodies useful in immunological assays to identify prions in tissues and body fluids. Mice are immunized with recombinant fragments of PrP<sup>c</sup> and the antibodies are used for therapeutic and preventive treatments of humans and animals. A hybridoma cell line was produced by administering to PrP<sup>0/0</sup> mice an immunizing amount of recombinant pure prion protein PrP ("A method of making an antibody **comprising administering a cellular form**", "A method of making a monoclonal antibody **comprising administering a cellular form**", "An antibody..binds **preferentially...**", "A monoclonal antibody...binds **preferentially...**" according to present claims 4 ,5,7,8). The spleen is removed and fused with myeloma cells. An antibody, i.e. 15B3, is produced that binds only native disease-specific PrP<sup>sc</sup> ("agent which binds the non-cellular form" according to present claim 15). Two other antibodies, i.e. 6H4 and 34C9 ("the antibody" according to present claim 15), bind to conserved or species specific regions respectively. To map the epitopes a peptide library ("sample" according to present claims 14, 15 and 18) is used. A method for the prevention of prion disease is described by administering to a patient a monoclonal antibody which is specific for PrP<sup>Sc</sup> ("A method as claimed ...for use in medicine..." according to present claim 21). A test kit is disclosed for the diagnosis of prion diseases comprising monoclonal antibodies ("A kit" according to present claim 23).

Claim 4 is anticipated by D3. D3 (page 14280, left column, second paragraph) describes an anti-rabbit polyclonal antibody raised against a synthetic peptide corresponding to residues 90-145 of PrP ("a method of making an antibody" according to present claim 6).

2.2 Claims 1-3,10,11,13,16, 17, 19, 20,22 are not disclosed in the prior art documents and are therefore novel.

3. Inventive Step (Article 33(3) PCT)

3.1 The subject matter of claims 1-3, 10, 11, 13 would appear to involve an inventive step.

D2 (see Section 3.1) is considered to be the closest prior art. Claims 1 and 3 differ

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International application No. PCT/GB00/02873

from D2 in that they relate to a defined sequence, part of the prion protein cellular form.

The technical problem to be solved would appear to reside in finding further applications of the sequence of the prion protein cellular form.

The skilled person, equipped with the knowledge of D2, would not be motivated to arrive at the subject matter of claims 1 and 3, since the sequence in the region of 176 to 221 of PrP<sup>c</sup> has anomalous protection factors and a particularly stable conformation. There is no indication in the prior art that exploits this property in making a peptide for use in the discrimination of PrP<sup>c</sup> and PrP<sup>sc</sup>. Therefore, claims 1-3, relating to peptides, and claim 13, relating to a binding agent (see section VIII also) derived from such a peptide, would appear to involve an inventive step.

3.2 Claims 10 and 11, relating to methods of making binding agents based on the peptides of claims 1-3, would appear consequently also to involve an inventive step.

3.3 Dependent claims 16, 17, 19, 20 and 22 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step, since the additional method steps (claims 16 and 17), alternative fluid samples (claims 19 and 20) or the diagnosis of the prion disease (claim 22) are considered as mere alternatives to the skilled person, which has the antibodies such as 6H4, 34C9 or 15B3 available, without resulting in any unexpected effect, whatsoever.

4. The priority of the present application is validly claimed. Therefore, D4 does not belong to the state of the art as defined in Rule 64.1 PCT.

## **SECTION VII**

5. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D2 is not mentioned in the description, nor is this document identified therein.

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**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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**SECTION VIII**

6. The applicant attributes to the term "fragment or variant" in claims 1,3-5 a special meaning (see page 5, lines 15-22 and page 6, lines 15-18), which was not generally known in the technical field concerned at the relevant filing date and contravenes the requirement that the meaning needs to be clear from the wording of the claim alone (the Guidelines C-III 4.2, Article 6 PCT).
7. It is not clear from the wording of claim 25, which technical features are specified in the kit and therefore the requirements of Article 6 PCT are not met.
8. For the assessment of the present claim 13 on the question whether it is acceptable, no unified criteria exist in the PCT Contracting States. The EPO, for example, does not recognize products defined in terms of a process. A product is not rendered novel merely by the fact that it is produced by means of a new process. The products as such has to fulfill the requirements of patentability, i.e. they have to be new and inventive.
9. The term "preferentially" as used throughout the present set of claims renders the features following this term in the claims entirely optional and therefore the scope for which protection is sought is not clear (the Guidelines C-III 4.6; Article 6 PCT).

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16-08-2001

## CLAIMS:

1. ~~A peptide consisting of all or a fragment or variant of an amino~~  
5 acid sequence of a prion protein which exhibits stability when measured  
by hydrogen/deuterium amide exchange at pH 5.5.
2. A peptide as claimed in Claim 1, wherein the peptide exhibits a  
protection factor greater than the equilibrium constant between a native  
10 state and an unfolded state; the protection factor ( $K_{ex}/K_{im}$ ) being  
determined by calculating amide exchange rate constants ( $K_{ex}$  from a  
series  $^1H$ - $^{15}N$  HSQC spectra and using intrinsic amide exchange rates  
( $K_{im}$ ).
- 15 ~~3. A peptide as claimed in Claims 1 or 2~~ consisting of all or a  
fragment or variant of an amino acid sequence from residue number 176  
to 221 of one of the prion protein cellular form (PrP<sup>c</sup>) sequences shown in  
figure 5.
- 20 ~~4. A peptide as claimed in Claim 3~~, consisting of all or a fragment or  
variant of an amino acid sequence from residue number 179 to 218 of any  
one of the said PrP<sup>c</sup> sequences.
- 25 ~~5. A peptide, consisting of all, or a fragment or variant of an amino~~  
acid sequence of approximately ten residues which flank the disulphide  
bond between Cys 179 and Cys 214 in one of the PrP<sup>c</sup> sequences shown in  
figure 5.

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- 4 ~~X~~ A method of making an antibody comprising administering a cellular form (PrP<sup>C</sup>) of a prion protein or a peptide as claimed in any one of Claims 1 to <sup>3</sup>~~X~~ to an animal so as to generate an antibody response and collecting the antibody therefrom.
- 5  
5 ~~X~~ An antibody obtainable by a method as claimed in Claim <sup>4</sup>~~X~~ which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.
- 10 6 ~~X~~ An antibody which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.
- 7 ~~X~~ A method of making a monoclonal antibody comprising administering a cellular form (PrP<sup>C</sup>) of a prion protein or a peptide as  
15 claimed in any one of Claims 1 to <sup>3</sup>~~X~~ to an animal so as to generate an antibody response; subsequently fusing an antibody producing cell from the animal with a myeloma cell to form a hybridoma and obtaining a monoclonal antibody produced by the hybridoma.
- 20 8 ~~X~~ A monoclonal antibody obtainable by a method as claimed in Claim <sup>7</sup>~~X~~ which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.
- 9 ~~X~~ A monoclonal antibody which binds preferentially to a cellular form  
25 of a prion protein rather than a non-cellular form.
- 10 ~~X~~ A method of making a binding agent capable of binding to a cellular form of a prion protein comprising exposing a peptide as claimed

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in any one of Claims 1 to <sup>3</sup>~~X~~ to a sample whereby any binding agent can bind the peptide and collecting the binding agent so bound.

11 ~~X~~ A method as claimed in Claim <sup>10</sup>~~X~~ wherein the binding agent is an antibody.

12 ~~X~~ A binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.

10 13 ~~X~~ A binding agent as claimed in Claim <sup>12</sup>~~X~~ which is obtainable by the method of Claim <sup>10</sup>~~X~~.

14 ~~X~~ Use of an antibody or binding agent as claimed in any one of Claims <sup>5</sup>~~X~~, <sup>8</sup>~~X~~, <sup>9</sup>~~X~~, <sup>12</sup>~~X~~ or <sup>13</sup>~~X~~ in a method of detecting a cellular form of a prion protein comprising exposing a sample to the antibody or binding agent and detecting binding of the antibody or binding agent to the cellular form of a prion protein.

15 ~~X~~ Use of an antibody or binding agent as claimed in any one of Claims <sup>5</sup>~~X~~, <sup>8</sup>~~X~~, <sup>9</sup>~~X~~, <sup>12</sup>~~X~~ or <sup>13</sup>~~X~~ in a method of detecting a non-cellular form of a prion protein comprising a first step of exposing a sample to the antibody or binding agent; a second step of exposing the sample to an agent which binds the non-cellular form of a prion protein; and detecting binding of the agent to the non-cellular form.

25 17 ~~X~~ Use as claimed in Claim <sup>15</sup>~~X~~ wherein the antibody or binding agent which has bound the cellular form is separated from the sample prior to the second step.

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- 17 ~~28~~. Use as claimed in Claim <sup>15</sup>~~27~~ or <sup>16</sup>~~28~~ wherein the antibody or binding agent in the first and/or second step is immobilised.
- 18 ~~28~~. A method of removing a cellular form of a prion protein from a sample comprising exposing the sample to an antibody or binding agent as claimed in any one of Claims <sup>5</sup>~~7~~, <sup>8</sup>~~10~~, <sup>9</sup>~~11~~, <sup>12</sup>~~14~~ or <sup>13</sup>~~18~~ and separating the sample from the antibody or binding agent which has bound the cellular form.
- 10 ~~28~~. <sup>19</sup>~~21~~. A method or use as claimed in any one of Claims <sup>10</sup>~~12~~, <sup>11</sup>~~13~~, <sup>14</sup>~~15~~ to <sup>18</sup>~~28~~ wherein the sample consists of or comprises a bodily fluid or tissue.
- 20 ~~28~~. A method as claimed in Claim <sup>19</sup>~~21~~ wherein the sample is selected from one or more of blood, or a component thereof such as plasma; cerebrospinal fluid; lymph; faeces; urine; sputum; tissue from a lymph node, appendix, tonsil and spleen.
- 21 ~~28~~. A method as claimed in any one of Claims <sup>14</sup>~~16~~ to <sup>20</sup>~~22~~ for use in medicine, preferably in the prevention, treatment and/or diagnosis of a prion disease.
- 22 ~~28~~. A method as claimed in Claim <sup>21</sup>~~23~~ wherein the method is for use in the diagnosis of the presence of a prion disease or a predisposition to such a disease.
- 23 ~~28~~. A kit comprising means for carrying out the methods of any one of Claims <sup>14</sup>~~16~~ to <sup>22</sup>~~24~~.

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~~24~~ ~~26~~ An antibody or binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form of a prion protein, for use in medicine, preferably in the prevention, treatment and/or diagnosis of a prion disease.

5

~~25~~ ~~28~~ A peptide sequence of a cellular form of a prion protein which exhibits stability when measured by hydrogen/deuterium amide exchange at pH 5.5, substantially as described herein with reference to one or more of the methods and/or accompanying figures.

10

~~26~~ ~~28~~ An antibody or binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form, substantially as described herein with reference to one or more of the methods and accompanying figures.

15

~~27~~ ~~29~~ A method of using an antibody and/or binding agent as claimed in Claim ~~28~~ <sup>26</sup>, the method being substantially as described herein with reference to one or more of the examples and accompanying figures.

~~20~~ ~~28~~ ~~30~~ Any novel subject-matter disclosed herein.

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International Preliminary Examining Authority  
European Patent Office  
Erhardtstrasse 27  
D-80298 Munchen  
GERMANY

15 August 2001

**Sent by fax**

Dear Sirs

International Patent Application No. PCT/GB00/02873  
IMPERIAL COLLEGE INNOVATIONS LIMITED  
**Our Ref:** ICOT/P23197PC

This is in response to the Written Opinion dated 15 May 2001.

We enclose manuscript amended claims pages 56-60.

***Amendments***

Claims 1 and 2 have been deleted. Consequential numbering changes have been made.

Any amendment is not to be construed as an abandonment of subject matter. On the contrary, the claims of the application have been amended here solely for the purpose of international examination to account for the unsearched and unexamined subject matter.

***Summary of the Invention***

Prion proteins are naturally produced proteins that, ordinarily, are not involved in disease. In this (natural) state, a prior protein has a conformation referred to as PrP<sup>C</sup>. However, an isoform of PrP<sup>C</sup> exists, having enriched  $\beta$ -sheet structure, termed PrP<sup>Sc</sup>. It is PrP<sup>Sc</sup> that is disease associated. However, PrP<sup>C</sup> and PrP<sup>Sc</sup> are identical in primary sequence. The only difference is in conformation. This, of course, poses problems for

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15 August 2001

the detection of disease-associated PrP<sup>Sc</sup>, because it is necessary to discriminate between two proteins, PrP<sup>C</sup> and PrP<sup>Sc</sup>, that are identical in sequence.

Discrimination between PrP<sup>Sc</sup> and PrP<sup>C</sup> therefore requires a conformation-sensitive assay. However, within the population of any protein a variety of conformations exist, as regions of the protein flux between folded, partially unfolded and fully unfolded. It is, therefore, no straightforward task to devise an assay that can reliably discriminate between two conformational states of the same protein.

This problem is addressed by the present invention. The inventors have found that a region of PrP<sup>C</sup> (residues 176-221) comprises residues having anomalously high protection factors. This could not have been predicted by the skilled person based on the equilibrium constant. Thus, surprisingly, the region 176-221 has a highly stable conformation, which is only disrupted when PrP<sup>C</sup> is converted to PrP<sup>Sc</sup>. The conformation of region 176-221 of PrP<sup>C</sup> is thus highly characteristic of PrP<sup>C</sup>. Based on this new finding, the inventors have provided means for the development of binding agents, such as antibodies, that can discriminate between PrP<sup>C</sup> and PrP<sup>Sc</sup>, and assays utilising those binding agents.

### ***Novelty***

*Claims 10, 13, 14 and 15 are novel over D1*

Claim 10 relates to a method of making a binding agent. The method requires a peptide according to any one of claims 1 to 3. D1 does not disclose such a peptide. Hence, D1 is missing, *inter alia*, an essential element of the method of Claim 10. Therefore Claim 10 is novel over D1.

Claim 13 is directed to a binding agent obtainable by the method of Claim 10. In other words, Claim 13 relates to a binding agent that binds a protein having, *at most*, residues 176-221 of a PrP<sup>C</sup>. D1 discloses a hypothetical protein termed a 'Prion Protein Modulation Factor' (PPMF) which binds to the residues 172, 215 and 219 of PrP<sup>C</sup> (see page 11, lines 5-13 and page 30, lines 17-19. These three residues together form a three-dimensional arrangement that is recognised by PPMF. The proteins of the present

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invention clearly lack at least one (ie, residue 172) or more of these three essential residues. Thus the proteins of the present invention are not capable of forming the three-dimensional structure that is recognised and bound by PPMF. Accordingly, PPMF would not have been identified and isolated by a method of Claim 10. Therefore, PPMF is not a binding agent obtainable by a method of Claim 10, and so Claim 13 is novel over D1.

Claims 14 and 15 relate to the use of the subject matter of Claims 5, 8, 9, 12 and 13. Claims 5, 8 and 13 are novel (Claims 9 and 12 being unexamined). The use of novel subject matter must also be novel. Accordingly Claims 14 and 15 are novel over D1.

*Claims 4, 7, 10, 11, 13-15, 18-21 and 23 are novel over D2*

Claims 4, 7, 10 and 11 relate to methods that require a peptide according to any one of claims 1 to 3. D2 does not disclose such a peptide. Hence, D2 is missing, *inter alia*, an essential element of the methods of Claims 4, 7, 10 and 11. Therefore Claims 4, 7, 10 and 11 are novel over D2.

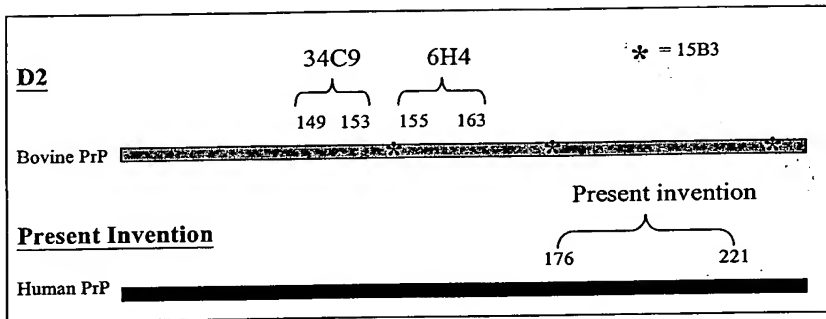
Claims 13-15, 18-21 and 23 relate to an antibody or binding agent identified as binding to *specific fragments of human PrP* protein, a use thereof, a method using the antibody or binding agent and a kit comprising the means for carrying out that method.

By contrast D2 relates to monoclonal antibodies raised against *bovine PrP*. Thus the protein used to antibodies in D2 is not only different to the protein used in the present invention, but it is also derived from a different organism. There is no reason to believe that the antibodies of D2 (identified as binding to bovine PrP) would bind to a human PrP protein as in the present invention. Thus Claims 13-15, 18-21 and 23 are novel over D2.

Moreover, even if an antibody raised against bovine PrP did bind to a human PrP protein (for which there can be non reasonable expectation), the three antibodies (6H4, 34C9 and 15B3) identified and described in D2 bind specific regions of bovine PrP that are different to the 176-221 protein of the present invention (see figure below).

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6H4 binds to residues 155-163 of bovine PrP (D2, page 31, lines 12-13). 34C9 binds to residues 149-153 of bovine PrP (D2, page 31, line 17). There is no overlap with the the 176-221 protein of the present invention. This is shown in the figure above.

Moreover, antibody 15B3 of D2 binds to a discontinuous epitope having three regions, the first between 153 and 159, the second between 173 and 181 and the third between 225 and 237. Thus, two of the three binding sites do not fall within the region of 176-221. Furthermore, there is only a *possibility* (but not a probability) that the middle binding site of 15B3 will fall within the region 176-221. Thus at best, antibody 15B3 may bind one binding site out of the necessary three in a peptide of the present invention. In fact, antibody 15B3 may not have any binding sites at all in a peptide of the present invention. Thus, even with one binding site, 15B3 would not be isolated by a method of identifying binding agents as described in Claim 12. Nor would 15B3 be produced by a method of making an antibody according to Claim 6 or 9.

Thus none of the antibodies provided by D2 would be identified and isolated by methods of the present invention because they would not bind to a protein of the present invention. Thus none of 6H4, 34C9 and 15B3 are a binding agent as defined by Claims 13-15, 18-21 and 23.

cont/....

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For all of these reasons Claims 13-15, 18-21 and 23 are novel over the disclosures of D2.

*Claim 4 is novel over D3*

The protein of D3 comprises residues 90-145. The protein of the present invention comprises residues 176-221. There is no overlap between the protein of D3 and the protein of the present invention. They are wholly different proteins. Therefore, D3 cannot disclose a method according to Claim 4 because it does not provide a protein according to the present invention. Thus Claim 4 is novel over D3.

*Inventive Step*

The present invention is the first study to show that residues in the region 176-221 of PrP<sup>C</sup> have anomalous protection factors. It could not have been predicted that residues in this region would have had protection factors in excess of that predicted from the equilibrium constant. Thus the skilled person would be surprised that the region 176-221 of PrP<sup>C</sup> has a particularly stable conformation.

In the absence of this knowledge, there is nothing in the prior art to motivate a person to manufacture a protein as defined in any of Claims 1-3, nor to use them in the production of binding agents, such as antibodies, for use in assays for discrimination between PrP<sup>C</sup> and PrP<sup>Sc</sup>.

Thus all claims of the present application are inventive over D1-D3.

*Other Matters*

If necessary, the objections raised in sections VII and VIII will be addressed



Page 6 of 6  
International Preliminary Examining Authority  
15 August 2001

in the national/regional phase of this application.

Yours faithfully  
ERIC POTTER CLARKSON

A handwritten signature in black ink, appearing to be 'PT' or similar initials, written over the printed name Eric Potter Clarkson.

Philip Thomas

ajw/jad

Enc: Manuscript amended pages 56-60

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(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
1 February 2001 (01.02.2001)

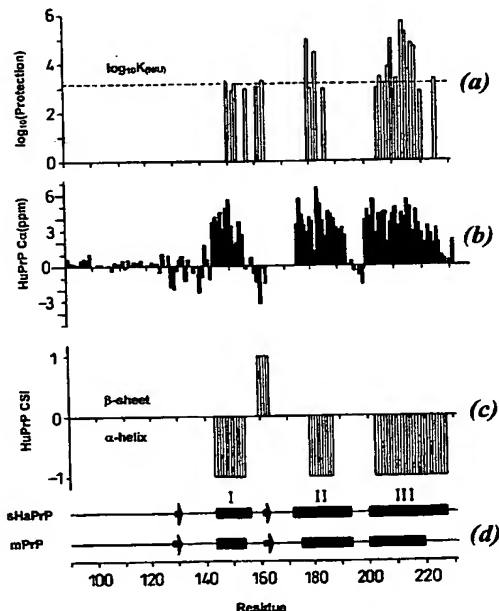
PCT

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**WO 01/07479 A3**

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- (21) International Application Number: PCT/GB00/02873
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[Continued on next page]

(54) Title: FRAGMENTS OF CELLULAR PRION PROTEIN AND METHODS USEFUL IN THE DIAGNOSIS AND TREATMENT OF PRION DISEASES



(57) Abstract: The invention relates to peptides and binding agents such as antibodies and uses thereof, especially in medicine, notably in the treatment, prevention, and/or diagnosis of prion diseases.

WO 01/07479 A3

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

IT, LU, MC, NL, PT, SE). OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— with international search report

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(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/GB 00/02873

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07K14/47 C07K16/18 G01N33/68

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07K G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, BIOSIS, WPI Data, PAJ, CHEM ABS Data, STRAND

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 55132 A (UNIV CALIFORNIA) 10 December 1998 (1998-12-10)  claims; figure 3; examples	3-7, 9, 12, 13, 16-18, 23, 24
X	WO 98 37210 A (ZUERICH ERZIEHUNGSDIREKTION ;KORTH CARSTEN (CH); OESCH BRUNO (CH);) 27 August 1998 (1998-08-27)  seq id no. 9 claims; examples	3-7, 9, 12, 13, 16-18, 23, 24



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

### \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*Z\* document member of the same patent family

Date of the actual completion of the international search

24 January 2001

Date of mailing of the international search report

05/02/2001

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# INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 00/02873

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>SCOTT MICHAEL R ET AL: "Identification of a prion protein epitope modulating transmission of bovine spongiform encephalopathy prions to transgenic mice." PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES, vol. 94, no. 26, 23 December 1997 (1997-12-23), pages 14279-14284, XP002158407 Dec. 23, 1997 ISSN: 0027-8424 page 14282, right-hand column, paragraph 5 -page 14283, left-hand column, paragraph 1</p>	3-7
P,X	<p>DATABASE BIOSIS 'Online! BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US; August 1999 (1999-08) HOSSZU LASZLO L P ET AL: "Structural mobility of the human prion protein probed by backbone hydrogen exchange." Database accession no. PREV199900385677 XP002158408 abstract &amp; NATURE STRUCTURAL BIOLOGY, vol. 6, no. 8, August 1999 (1999-08), pages 740-743, ISSN: 1072-8368</p>	3-25

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## FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

## Continuation of Box I.1

As far as claim(s) 23 and 24 are directed to a diagnostic method practised on the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

As far as claim 23 is directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.

## Continuation of Box I.2

Claims Nos.: 1,2,8,11,14,26-29

Present claims 1, 2 and 27 relate to a compound defined (inter alia) by reference to the following parameter(s): it exhibits stability when measured by hydrogen/deuterium amide exchange at pH 5.5.

The use of these parameters in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameters the applicant has chosen to employ with what is set out in the prior art. The lack of clarity is such as to render a meaningful complete search impossible. Consequently, the search has been restricted to peptides consisting of all or a fragment or variant of an amino acid sequence from residue number 176 to 221 or the prpc according to figure 5 (including dependent claims thereof and including antibodies against peptides and methods and uses thereof)

Present claims 8, 11, 14, 26 and 28-29 relate to a product defined by reference to a desirable characteristic or property, namely the ability to bind preferably to cellular prion protein than to prion protein sc.

The claims cover all products having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT for only a very limited number of such products. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the product by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible. Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the products which bind to peptide sequences derived from the region between positions 176 to 221 of the cellular prion protein.

Present claim 30 was search within the scope of other claims searched.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant

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FURTHER INFORMATION CONTINUED FROM PCT/SA/ 210

is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

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# INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9855132 A	10-12-1998	US 5962669 A	05-10-1999
		AU 7796798 A	21-12-1998
		EP 0986396 A	22-03-2000
WO 9837210 A	27-08-1998	EP 0861900 A	02-09-1998
		AU 6498698 A	09-09-1998
		EP 1007700 A	14-06-2000

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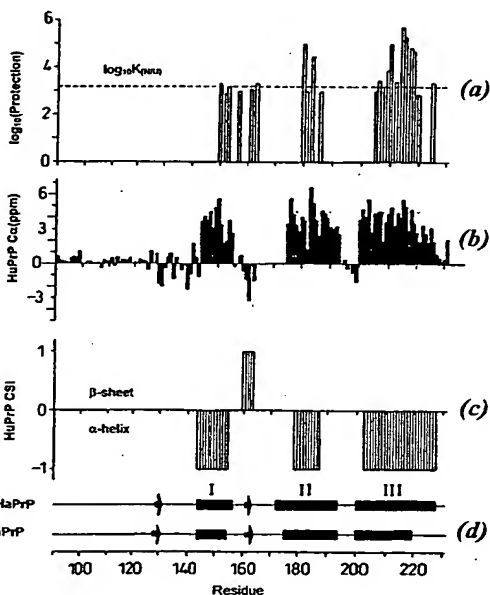
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(54) Title: BIOLOGICAL MATERIALS AND METHODS USEFUL IN THE DIAGNOSIS AND TREATMENT OF DISEASES



(57) Abstract: The invention relates to peptides and binding agents such as antibodies and uses thereof, especially in medicine, notably in the treatment, prevention, and/or diagnosis of prion diseases.

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BIOLOGICAL MATERIALS AND METHODS USEFUL IN THE  
DIAGNOSIS AND TREATMENT OF DISEASES

The present invention relates to prion proteins.

5

Prions are infectious pathogens that differ from bacteria, fungi, parasites, viroids, and viruses, both with respect to their structure and with respect to the diseases that they cause. Molecular biological and structural studies of prions promise to open new vistas into fundamental mechanisms of cellular regulation and homeostasis not previously appreciated. Kuru, Creutzfeldt-Jakob disease (CJD), fatal familial insomnia (FFI) and Gerstmann-Sträussler-Scheinker syndrome (GSS) are all human neurodegenerative diseases that are caused by prions and are frequently transmissible to laboratory animals. Familial CJD and GSS are also genetic disorders. No effective therapy exists to prevent these fatal disorders<sup>2</sup>.

15

In addition to the prion diseases of humans, disorders of animals are included in the group of known prion diseases. Scrapie of sheep and goats is the most studied of the prion diseases. Bovine spongiform encephalopathy (BSE) is thought to result from abnormal feeding practices. BSE threatens the beef industry of Great Britain and possibly other countries; the production of pharmaceuticals involving cattle is also of concern. Control of sheep scrapie in many countries is a persistent and vexing problem<sup>2</sup>.

20

Since 1986, more than 170,000 cattle have developed BSE in Great Britain. Many investigators contend that BSE, often referred to as "mad cow disease", resulted from the feeding of dietary protein supplements

derived from rendered sheep offal infected with scrapie to cattle, a practice banned since 1988. It is thought that BSE will disappear with the cessation of feeding rendered meat and bone meal, as has been the case in kuru of humans, confined to the Fore region of New Guinea and once the  
5 most common cause of death among women and children. Kuru has almost disappeared with the cessation of ritualistic cannibalism.

Prion diseases are associated with the accumulation of a conformational isomer ( $\text{PrP}^{\text{Sc}}$ ) of host-derived prion protein ( $\text{PrP}^{\text{C}}$ ) with an increase in its  
10  $\beta$ -sheet content<sup>1</sup>. According to the protein-only hypothesis,  $\text{PrP}^{\text{Sc}}$  is the principal or sole component of transmissible prions<sup>2</sup>. Although the structure of  $\text{PrP}^{\text{C}}$  has been determined<sup>3</sup> and has been found to consist predominantly of  $\alpha$ -helices, the insolubility of  $\text{PrP}^{\text{Sc}}$ , which is isolated from tissue in a highly aggregated state and which has a high  $\beta$ -sheet  
15 content, has precluded high-resolution structural analysis.

The detection of the disease-associated isoform of prion protein,  $\text{PrP}^{\text{Sc}}$ , in brain or other tissues from patients is thought to be diagnostic of prion disease. To distinguish  $\text{PrP}^{\text{Sc}}$  from its cellular precursor,  $\text{PrP}^{\text{C}}$ , requires  
20 either pre-treatment with proteinase K, which will completely digest  $\text{PrP}^{\text{C}}$ , but only removes a protease-sensitive N-terminal of  $\text{PrP}^{\text{Sc}}$  or, alternatively, would require an antibody which distinguished between  $\text{PrP}^{\text{C}}$  and  $\text{PrP}^{\text{Sc}}$ . Only one such selective antibody (Korth C. *et al.* 1997 *Nature* 390, 74-77) has yet been reported and appears to be able to  
25 selectively immunoprecipitate  $\text{PrP}^{\text{Sc}}$ . It is not clear as yet, however, whether this antibody offers any increase in diagnostic sensitivity over existing monoclonals. It is an IgM antibody and is likely to be of low affinity for  $\text{PrP}^{\text{Sc}}$ .

We have discovered that located around the disulphide bond of the cellular ( $\alpha$ ) form of a prion protein,  $\text{PrP}^C$ , is a nucleus of structure that persists in the unfolded state of the molecule. This nucleus of structure is a specific  
5 marker of  $\text{PrP}^C$  and not  $\text{PrP}^{\text{Sc}}$ . These unexpected findings concerning a hyper-stable region around the disulphide bond of the cellular form of the prion protein ( $\text{PrP}^C$ ) have been exploited in the present invention to provide materials and methods which are useful in medicine, especially in the research, diagnosis, prevention and/or treatment of diseases associated  
10 with prion proteins, namely spongiform encephalopathies such as Scrapie in sheep, BSE in cows and CJD in humans.

According to a first aspect the invention provides a peptide consisting of all or a fragment or variant of an amino acid sequence of a prion protein  
15 which exhibits stability when measured by hydrogen /deuterium amide exchange at pH 5.5.

Preferably, the peptide exhibits a protection factor greater than the equilibrium constant between a native state and an unfolded state; the  
20 protection factor ( $K_{\text{ex}}/K_{\text{im}}$ ) being determined by calculating amide exchange rate constants ( $K_{\text{ex}}$ ) from a series  $^1\text{H}$ - $^{15}\text{N}$  HSQC spectra and using intrinsic amide exchange rates ( $K_{\text{im}}$ ).

Advantageously, a peptide of the invention consisting of all or a fragment  
25 or variant of an amino acid sequence from residue number 176 to 221 of one of the prion protein cellular form ( $\text{PrP}^C$ ) sequences shown in figure 5, and preferably consists of all or a fragment or variant of an amino acid sequence from residue number 179 to 218 of any one of the said  $\text{PrP}^C$  sequences.

The invention also provides a peptide consisting of all, or a fragment or variant of an amino acid sequence of approximately ten residues which flanks the disulphide bond between Cys 179 and Cys 214 in one of the  
5 PrP<sup>C</sup> sequences shown in figure 5.

The disease-related isoform of PrP, PrP<sup>Sc</sup>, is distinguished biochemically from the normal cellular isoform of the protein, PrP<sup>C</sup>, by its partial resistance to digestion with the enzyme proteinase K.

10

By "cellular form" of a prion protein we include any form of a prion protein which does not exhibit partial resistance to digestion with proteinase K (PK).

15 By "partial resistance to digestion with proteinase K (PK)" we include the meaning that after incubation of 1 mg/ml of the protein in 10mM NaAcetate + 10mM Tris. Acetate, pH 8.0 with 0.5 µg/ml PK (based on the total digestion reaction volume) at 37°C for 30 minutes some protein can be shown to be undigested when subjected to SDS-PAGE as described  
20 herein. Preferably, the majority of the protein is undigested.

Preferably, the non-cellular form displays resistance to digestion at increased concentrations of PK eg 5 µg/ml PK or more.

25 Non-cellular forms of a prion protein referred to herein exhibit partial resistance to digestion with PK and include PrP<sup>Sc</sup> and the β-form as reported recently by Jackson *et al*, *Science* (March 1999) 283, pp 1933-1937.

The invention also provides a peptide of the invention for use in medicine, preferably in the prevention, treatment and/or diagnosis of a prion disease.

Preferably, the peptide sequence is selected from human, bovine or ovine  
5 prion proteins, more preferably human prion protein.

It will be appreciated that peptides of the invention include variants, fragments and fusions that have interactions or activities which are substantially the same as those of the stable core sequence of PrP<sup>C</sup>. A  
10 relevant activity of the variants, fragments, or fusions of the invention is the ability to raise an antibody which binds preferentially to the cellular form of a prion protein, PrP<sup>C</sup>, rather than the non-cellular form, such as PrP<sup>Sc</sup>.

15 A "variant" will have a region which has at least 80% (preferably 85, 90, 95 or 99%) sequence identity with the stable core region of cellular human PrP<sup>C</sup> sequence described herein or the corresponding region in the PrP<sup>C</sup> of other species as measured by the Bestfit Program of the Wisconsin Sequence Analysis Package, version 8 for Unix. The percentage identity  
20 may be calculated by reference to a region of at least 10 amino acids (preferably at least 20, 30, 40 or 45) of the candidate variant molecule, and the most similar region of equivalent length in the native region.

The percent identity may be determined, for example, by comparing  
25 sequence information using the GAP computer program, version 6.0 described by Devereux et al. (*Nucl. Acids res.* 12:387, 1984) and available from the University of Wisconsin Genetics Computer Group (UWGCG). The GAP program utilizes the alignment method of Needleman and Wunsch (*J. Mol. Biol.* 48:443, 1970), as revised by Smith

and Waterman (*Adv. Appl. Math.* 2:482, 1981). The preferred default parameters for the GAP program include : (1) a unary comparison matrix (containing a value of 1 for identities and 0 for non-identities) for nucleotides, and the weighted comparison matrix of Bribskov and Burgess, *Nucl. Acids Res.* 14:6745, 1986 as described by Schwarts and Dayhoff, eds, *Atlas of Protein Sequence and Structure*, National Biomedical Research Foundation, pp 353-358, 1979; (2) a penalty of 3.0 for each gap and an additional 0.10 penalty for each symbol in each gap; and (3) no penalty for end gaps.

10

The term "variants" is intended to embrace prion protein sequence variations between species, in particular, the known variations at residue numbers 184, 186, 203, 205, 215, 219 and 220 (see Figure 5).

15 A "fragment" comprises any peptide sequence which is antigenic ie capable of reacting with antibody a PrP<sup>C</sup> specific and preferably is immunogenic ie capable of generating a PrP<sup>C</sup> specific antibody response itself. The peptide sequence of the fragment will preferably comprise at least 45, preferably 6, 8, 10 or 12 or more amino acids of the native 176  
20 to 221 PrP<sup>C</sup> sequences described herein.

According to a further aspect of the invention there is provided a method of making an antibody comprising administering a cellular form (PrP<sup>C</sup>) of a prion protein or a peptide as defined in accordance with the earlier  
25 aspects of the invention, or a mixture of two or more of the peptides to an animal and collecting and optionally purifying the resulting antibody.

By "antibody" in accordance with the invention we include molecules which comprise or consist of antigen binding fragments of an antibody

including Fab, Fv, ScFv and dAb. We also include agents which incorporate such fragments as portions for targetting prion molecules and/or prokaryotic or eukaryotic cells or viruses which display such molecules.

5

According to this aspect of the invention, there is also provided a monoclonal antibody capable of distinguishing between the cellular form of a prion protein, PrP<sup>C</sup>, and the non-cellular form of a prion protein (eg PrP<sup>Sc</sup>) as defined in accordance with earlier aspects of the invention. Also  
10 provided is a hybridoma cell capable of producing such a monoclonal antibody.

The invention also provides a method of making a binding agent capable of binding to a cellular form of a prion protein comprising exposing a  
15 peptide of the invention to a sample whereby any binding agent can bind the peptide and collecting the binding agent so bound. Preferably, the binding agent is an antibody.

The invention also provides a binding agent, which is preferably  
20 obtainable by the above method, which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.

The invention also provides the use of an antibody or binding agent in a method of detecting a cellular form of a prion protein comprising exposing  
25 a sample to the antibody or binding agent and detecting binding of the antibody or binding agent to the cellular form of a prion protein.

There is also provided the use of an antibody or binding agent of the invention in a method of detecting a non-cellular form of a prion protein

comprising a first step of exposing a sample to the antibody or binding agent; a second step of exposing the sample to an agent which binds the non-cellular form of a prion protein; and detecting binding the agent to the non-cellular form.

5

Preferably, the antibody or binding agent which has bound the cellular form is separated from the sample prior to the second step.

Conveniently, the antibody or binding agent in the first and/or second step  
10 is immobilised.

The invention also provides a method of removing a cellular form of a prion protein from a sample exposing the sample to an antibody or binding agent of the invention and separating the sample from the antibody or  
15 binding agent which has bound the cellular form.

The invention also provides a method of detecting antibodies in a sample, which antibodies bind preferentially to a non-cellular form of a prion protein rather than the cellular form, comprising exposing a peptide of the invention  
20 to the sample to permit binding of antibody to the peptide; and subsequently exposing the non-cellular form to the sample and detecting the binding of antibody to the non-cellular form. Optionally, the cellular and/or non-cellular form is immobilised before exposure to the sample.

25 The invention further provides a method of the invention for use in the prevention, treatment and/or diagnosis of a prion disease. Preferably, the method is for use in the diagnosis of the presence of a prion disease or a predisposition to such a disease.



The invention also provides a peptide of the invention, or an antibody or binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form of a prion protein, for use in medicine, preferably in the prevention, treatment and/or diagnosis of a prion disease.

The prion disease may be selected from one or more of the diseases affecting humans. Alternatively or additionally, the prion diseases are selected from one or more of the diseases which affect domestic farm animals such as cows, sheep and goats. Other prion diseases include transmissible mink encephalopathy; chronic wasting disease of mule deer and elk, bovine spongiform encephalopathy and, more recently, a whole series of new animal diseases that are thought to have arisen from their dietary exposure to the BSE agent. These include feline spongiform encephalopathy, affecting domestic cats and captive wild cats (such as cheetahs, pumas, ocelots, tigers) and spongiform encephalopathies of captive exotic ungulates (including kudu, nyala, gemsbok, eland).

The invention also provides a kit comprising means for carrying out the methods of the invention.

The invention also provides a kit useful for diagnosing a prion disease comprising a binding agent, preferably an antibody, which is capable of preferentially binding the cellular form rather than the non-cellular form, and means for detecting binding of the binding agent to the cellular form. Optionally, the binding agent is coupled to an inert support. Preferably, the means for detecting binding comprises a radioactive, enzymic or fluorescent label. Preferably, the kit further comprises a binding agent, preferably an antibody, which is capable of binding the non-cellular form of a prion

protein and means to detect binding of the binding agent to the non-cellular form.

Preferably, in the methods of the invention the sample comprises or  
5 consists of a bodily tissue or fluid, which may be blood or a derivative of blood, ie a component such as plasma, or is derived from lymphoid tissue (such as tonsils, appendices, lymph nodes or spleen) or is cerebrospinal fluid, or faeces, urine or sputum, for example. The biological sample may be a tissue sample eg a biopsy tissue sample.

10

By "preferentially" according to the various aspects of the invention we include the meaning that the ratio of noncellular/cellular binding may be 45/55, 25/75, more preferably, 10/90, 5/95, 1/99 or substantially 0/100.

15 Preferred non-limiting embodiments of the invention will now be described by way of example with reference to the following figures in which:

*Figure 1*

20

Aromatic CD measured at 290 nm is shown as open triangles, overlaid with amide CD measured at 222 nm, shown as open circles. The lines superimposed upon the data are fits to the function:

25

$$\alpha_N = (K_{(N/U)} \cdot \exp(m \cdot D)) / (1 + K_{(N/U)} \cdot \exp(m \cdot D))$$

where m represents the sensitivity of the unfolding transition to denaturant and D is the denaturant activity <sup>24</sup>.

**Figure 2**

- (a) Amide protection factors ( $K_{ex}/K_{int}$ ) of the residues with quantifiable protection in human PrP<sup>C</sup> (HuPrP). The protection factor corresponding to the equilibrium constant between the native (N) and unfolded (U) states is plotted as a horizontal dashed line ( $\log_{10}K_{(N/U)}$ ). Regions of highest protection (greater than  $K_{(N/U)}$ ) are in close proximity to the disulphide bond between helices II and III (see figure 4).
- (b) C $^{\alpha}$  chemical shift deviations from random coil values for residues not preceeding proline in human PrP<sup>C</sup> <sup>25</sup>. A very similar C $^{\alpha}$  chemical shift profile is observed in hamster PrP<sup>C</sup> (sHaPrP)<sup>26</sup> strongly suggesting that both proteins have very similar global folds.
- (c) Chemical Shift Index (CSI) of human PrP<sup>C</sup> calculated by the program CSI<sup>22</sup> using C $^{\alpha}$ /C $^{\beta}$ /C $^{\gamma}$  resonances, showing regions predicted to be  $\beta$ -sheet (values above line) and  $\alpha$ -helix (values below line). As found in sHaPrP, the first strand of the  $\beta$ -sheet (residues 129-131) observed in the solution structure is not identified by the CSI<sup>26</sup>, however residues 129 and 130 of HuPrP have a C $^{\alpha}$  chemical shifts consistent with an extended conformation (see (b)).
- (d) Secondary structure elements of hamster (sHaPrP) and mouse (moPrP) PrP<sup>C</sup>, in their respective NMR structures<sup>9,11,27</sup>.  $\alpha$ -helices are represented by cylinders and the  $\beta$ -sheet strands by arrows. The three main  $\alpha$ -helices are labelled I-III.

*Figure 3*

The decay curves of three representative amide protons within human PrP are shown: Val209 (open circles), Val210 (open squares) and Gln212 (open triangles). Superimposed on the data are fits to the first order rate equation,  $I_t = I_0 e^{(-k \cdot t)}$ , where  $I_t$  is the relative intensity at time  $t$ ,  $I_0$  is the initial intensity,  $t$  is time in secs and  $k$  is the first order rate constant.

*Figure 4*

10 Stereoview of protected amide protons in human PrP<sup>C</sup> displayed on the backbone conformation of mouse PrP<sup>C</sup> <sup>9</sup> (moPrP). (The human form of the protein differs from mouse by a number of point mutations which can be modelled onto the moPrP NMR structure with very little effect on its  
15 backbone conformation (Unpublished data)). Residues 124-226 are displayed, with  $\beta$ -strands coloured blue and  $\alpha$ -helices red. The ends of the helices are marked with roman numerals, with the numeral at the C-terminal end marked with an apostrophe. The disulphide bond between Cys179 and Cys214 is marked by a yellow dashed line between the C $^{\alpha}$   
20 atom of those residues. The C $^{\alpha}$  atoms of significantly protected amide groups are shown as spacefilled spheres with the radius of each proportional to  $\log_{10}$  (Protection Factor). This figure was produced using MidasPlus<sup>28,29</sup>.

*Figure 5*

25 Known prion protein sequences from various mammalian species, using the single letter code for amino acids as follows:

A=Ala; D=Asp; E=Glu, F=Phe; K=Lys; L=Leu; M=Met;  
N=Asn; P=Pro; Q=Gly; R=Arg; S=Ser; T=Thr; and V=Val.

Such information is available from databases such as EMBL, Genbank,  
5 Swis-Prot, Brookhaven.

The stable region runs from residues 176 to 221 and is highlighted by a  
box in Figure 5.

## 10 METHODS

### 1. *Sample Preparation*

Uniformly  $^{13}\text{C}/^{15}\text{N}$ -labelled human PrP<sup>C</sup> was expressed in E.coli using a  
15 EMBL minimal media recipe with  $^{13}\text{C}_6$ -glucose and  $(^{15}\text{NH}_4)_2\text{SO}_4$  as the  
sole carbon and nitrogen sources, and purified as previously described  
(Jackson *et al*, (1999) *Science* 283, pp 1933-1937.

### *Purification of human PrP*

20

### *Plasmid Design and Protein Expression*

The open reading frame of the human PrP gene was amplified by PCR  
using oligonucleotide primers designed to create an unique N-terminal  
25 BamHI site and C-terminal HindIII site for directional cloning of the  
fragment into the expression vector pTrcHisB (Invitrogen Corp.). The  
primer corresponding to the N-terminal region of PRNP to be expressed  
was designed to mutate a glycine at codon 90 to methionine, with the C-  
terminal primer replacing a methionine residue at 232 to a stop codon.

The ligated pTrcHisB/*PRNP* construct was used to transform the *E. coli* host strain BL21 (DE3) (Novagen), genotype F' *ompT hsdS<sub>B</sub> (r<sub>B</sub>m<sub>B</sub>) gal dcm* (DE3) which was then plated onto Luria-Bertoni (LB) agar plates  
5 containing 100µg/ml carbenicillin. Following growth overnight at 37°C single colonies were picked and used to inoculate 10 x 10ml of LB broth containing 100µg/ml carbenicillin. This culture was grown overnight at 37°C with vigorous shaking. The 10ml cultures were used as inocula for 10 x 1 litre of LB broth containing 100µg/ml carbenicillin which had been  
10 pre-warmed to 37°C. Growth at 37°C with vigorous shaking was allowed to progress until the culture reached an OD<sub>600</sub> of 0.6. Expression was then induced by addition of isopropyl-β-D-galactopyranoside to a final concentration of 1mM and the culture resupplemented with carbenicillin to a level of 100µg/ml. Following 4 hours of induced growth the cells were  
15 harvested by centrifugation at 8,500 rpm for 10 minutes.

#### *Extraction, Refolding and Purification of Recombinant Human PrP*

The cell pellet was resuspended in 50ml of lysis buffer (50mM Tris. Cl  
20 pH 8.0, 200mM NaCl, 0.1% Triton X100, 10µg/ml DNase 1, 10µg/ml lysozyme) and disrupted by sonication in 1 minute bursts for a total of 5 minutes. Centrifugation at 9,600 rpm for 30 minutes pelleted all the insoluble material and the supernatant was discarded. The pellet was then washed twice by resuspension in 50ml of lysis buffer with centrifugation  
25 at 7,500 rpm for 5 minutes between each wash. Solubilisation of protein in the pellet was performed by resuspension in 50ml of 50mM Tris. Cl, 6M GuHCl, 100mM DTT pH 8.0. Cell debris and insoluble material was removed by centrifugation at 9,600rpm for 30 minutes. The supernatant was clarified by passage through a 0.2µm filter and loaded onto a 20ml

Ni-NTA-Sepharose (Quiagen) column pre-equilibrated with 50mM Tris.Cl, 6M GuHCl pH 8.0.

After washing the column with the above buffer, bound protein was eluted  
5 with a 15 column volume linear gradient of 0mM to 300mM imidazole in  
loading buffer. Recombinant PrP eluted at 185mM imidazole. Eluted  
fractions were pooled and oxidation of disulphides was achieved by  
vigorous stirring in the presence of  $1\mu\text{M}$   $\text{CuSO}_4$  and dissolved atmospheric  
oxygen for 16 hours. PrP containing oxidised disulphides was separated  
10 from reduced protein using reverse phase chromatography on an RP304-  
C4 column. The protein was loaded in 50mM Tris.Cl, 6M GuHCl pH  
8.0, washed with  $\text{ddH}_2\text{O}$  + 0.1% trifluoroacetic acid (TFA) and eluted  
with a linear gradient of 15% to 60% acetonitrile + 0.09% TFA. Human  
PrP emerged as two major peaks; oxidised protein at 40% acetonitrile and  
15 a second peak containing reduced PrP eluted at 45% acetonitrile. The  
oxidised peak fractions were pooled and neutralised by the addition of 1M  
Tris.Cl pH 8.0 to a final concentration of 100mM and saturated  
ammonium sulphate added to a final concentration of 70%. Precipitated  
PrP accumulated at the interface between organic and aqueous phases and  
20 was removed to a separate container. The protein was solubilised in a  
minimal volume of 50mM Tris.Cl, 6M GuHCl pH 8.0 and then diluted  
rapidly to a protein concentration of 1mg/ml and dialysed for 16 hours  
against 50mM Tris.Cl pH 8.0 with a buffer change after 8 hours.  
Following dialysis the N-terminal fusion peptide was removed by addition  
25 of enterokinase at 1unit/3mg protein. Cleavage was allowed to occur at  
37°C for 14 hours and terminated by the addition of "protease complete"  
(Boehringer Mannheim Corp).

Final purification was carried out by applying the protein material to a 10ml S-Sepharose FastFlow column equilibrated with 25mM Tris.Cl pH 7.0 and following a 5 column volume wash with the same buffer, protein was eluted with a 10 column volume linear gradient of 0mM to 300mM NaCl. Recombinant PrP lacking the N-terminal fusion peptide eluted at 150mM whilst uncleaved material remained bound until 250mM NaCl. Eluted fractions were concentrated in an Amicon cell with a 10kDa cut off membrane and then dialysed overnight against 25mM Tris.Cl pH 7.0, 0.02% NaAzide containing a small amount of activated charcoal. Sucrose was added to 5% w/v and the protein snap frozen in liquid nitrogen for long term storage at -80°C.

## 2. *NMR spectroscopy*

NMR spectra were acquired at 303K on 12 mg/ml  $^{13}\text{C}/^{15}\text{N}$ -labelled sample in 20 mM sodium acetate- $\text{d}_3$ , 2mM Sodium Azide, pH 5.5 (10%(v/v)  $\text{D}_2\text{O}$ ) using Bruker DRX-500 and DRX-600 spectrometers. Backbone resonances ( $\text{H}^{\text{N}}$ ; N;  $\text{C}^{\alpha}$ ;  $\text{C}'$ ;  $\text{C}^{\beta}$ ) were assigned using a suite of triple-resonance NMR experiments<sup>18,19-21</sup>. Almost complete backbone assignments were determined, the exceptions being residues 164-172, which form an ill-defined loop in the mouse PrP<sup>C</sup> NMR structure<sup>9,11</sup>.  $\text{C}^{\alpha}$ ;  $\text{C}'$ ;  $\text{C}^{\beta}$  chemical shifts were used to calculate the chemical shift index (CSI) profile of human PrP<sup>C</sup><sup>22</sup>. NMR data were processed and analysed on Silicon Graphics Workstations using Felix 97 software (MSI Corp).

## 3. *Amide exchange*

Amide exchange was initiated by diluting the  $^{13}\text{C}/^{15}\text{N}$ -labelled human PrP<sup>C</sup> sample with an equal volume of 20 mM sodium acetate- $\text{d}_3$ , 2 mM Sodium



Azide, pH 5.5 dissolved in 100% D<sub>2</sub>O. The sample was equilibrated at 303K for 5 mins in a Bruker DRX-600 spectrometer and amide exchange rate constants ( $K_{ex}$ ) determined from a series <sup>1</sup>H-<sup>15</sup>N HSQC spectra. These were used to determine protection factors ( $K_{ex}/K_{im}$ ) for observable amides using intrinsic exchange rates ( $K_{im}$ )<sup>23</sup>. Acquisition of the first experiment began ~5 mins after mixing, setting a lower limit on the detection of protection factors of approximately 10.

#### 4. *Equilibrium denaturation data*

10

The amide C.D. absorption of 5 $\mu$ M PrP<sup>C</sup> dissolved in 20mM sodium acetate-d<sub>3</sub>, 2 mM Sodium Azide, pH 5.5 55% D<sub>2</sub>O was recorded in varying concentrations of GuHCl at 222 nm on a Jobin-Yvon CD6 spectropolarimeter through 1cm light path with an integration time of 120 sec. The ellipticity signal (O) was converted to proportion of molecules in the native state  $\alpha_N$  according to the relationship  $\alpha_N = (O - O_U)/(O_N - O_U)$ , where O<sub>U</sub> and O<sub>N</sub> are the ellipticity signals for the unfolded and native states respectively. Similarly the aromatic C.D. absorption response of 50 $\mu$ M PrP was measured at 290 nm through a 1cm light path at increasing denaturant concentration.

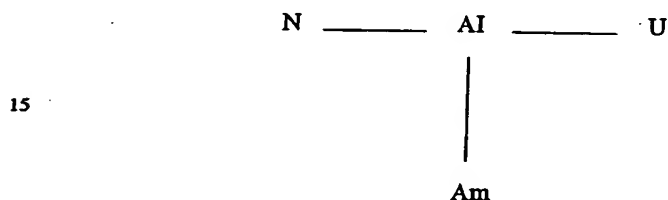
20

#### 5. *Results*

The accumulation of insoluble PrP<sup>Sc</sup> by recruitment of the native, cellular isoform of the prion protein (PrP<sup>C</sup>) is a characteristic of spongiform encephalopathies such as Scrapie in sheep, BSE in cows and CJD in humans<sup>1</sup>. It appears that the disease process can be triggered by inherited mutations in the encoding gene<sup>2,3</sup>, by infection with tissue containing PrP<sup>Sc</sup> or by a rare spontaneous event which gives rise to sporadic cases. *In vitro*

25

studies of prion proteins show that the chain can adopt a variety of folds depending on solution conditions<sup>4,5</sup>. The native, cellular form (PrP<sup>C</sup>) is capable of being switched between the largely  $\alpha$ -helical conformation, characteristic of this state, to a variety of other structures by changing  
 5 temperature, pH and/or redox conditions<sup>4</sup>. Most of these alternative states are dominated by  $\beta$ -sheet and form insoluble aggregates. Such observations have led to the proposal that the prion protein shows unusual conformations, enriched in  $\beta$ -sheet, which are in equilibrium with the native PrP<sup>C</sup> state. In turn these alternative conformers, or a subset  
 10 thereof, can then irreversibly associate to form amyloid rods<sup>6</sup>. This process is described most simply by the following scheme:



Where N is the native state, AI is an amyloidogenic folding intermediate  
 20 and Am is irreversibly aggregated amyloid material. In this model, formation of the prion amyloid can be promoted by mutations which increase the population of the amyloidogenic intermediate and by the introduction of stable amyloid material which can then recruit such an intermediate. This type of mechanism for the conversion of PrP<sup>C</sup> to PrP<sup>Sc</sup>  
 25 can, to some degree, be tested by comparing the free energy of unfolding of the PrP<sup>C</sup> protein with its local hydrogen exchange properties.

Shown in figure 1 are equilibrium denaturation profiles of human PrP<sup>C</sup> at pH 5.5 and 55% D<sub>2</sub>O; a condition chosen to match the hydrogen exchange

measurements described later. The amide and aromatic CD profiles show that the molecule denatures in a single transition to a state that retains some degree of backbone and aromatic organisation (~30% of the native signal). Analysis of the amide and aromatic transitions renders values of  
 5  $1.5 \times 10^3$  and  $1.7 \times 10^3$  respectively for the equilibrium constant  $K_{(N/U)}$  in the absence of denaturant.

The fact that there is no populated intermediate state during equilibrium denaturation in these conditions does not rule out the existence of a folding  
 10 intermediate (I) which, in water, is more stable than the unfolded state (U). Indeed, in most proteins such folding intermediates are only measurably populated in kinetic experiments where the unfolded state, in a denaturing solvent, is rapidly transferred to strong folding conditions. The folding reaction can then be written:

15



If  $K_{(U/I)}$  and  $K_{(N/I)}$  are greater than 1 and the 'U <-> I' equilibrium is fast (as with most proteins) then the intermediate, despite being more stable  
 20 than the unfolded state, is only seen as a transient species. Alternatively, or additionally, the native state (N) may be in equilibrium with a partially unfolded form (PUF)<sup>7</sup> so that the system can be written:



25

The question we wish to address is whether it is likely that PrP<sup>Sc</sup>, an aggregated  $\beta$ -sheet form of the prion protein, is generated from folding intermediates or partially unfolded forms which are rich in  $\beta$ -sheet structure and capable of forming strong intermolecular interactions. This

type of mechanism has recently been proposed for the formation of lysozyme amyloid<sup>8</sup>.

One way of examining this question is to measure the rate of hydrogen/deuterium exchange by NMR. This enables identification of those regions of the hydrogen-bonded backbone which remain stable until the molecule is fully unfolded. The observed rate of H/D exchange of an amide proton ( $k_{ex}$ ) is governed by its intrinsic exchange rate when exposed to the solvent ( $k_{int}$ ), and the rates of closing ( $k_c$ ) and opening ( $k_o$ ) of the hydrogen bond. The general expression relating these rate constants is

$$k_{ex} = (k_o \cdot k_{int}) / (k_c + k_{int})$$

In conditions where  $k_c > k_{int}$  (often termed the EX2 condition) the relationship reduces to  $k_{ex} = (k_o/k_c) \cdot k_{int}$  so that exchange data can be used to map the local equilibrium distribution between open and closed backbone hydrogen bonds. The average rate constant for intrinsic exchange at pH 5.5 is about  $0.1 \text{ sec}^{-1}$ , yet the native state signal in both the amide and aromatic regions of the C.D spectrum is gained within 20 milliseconds of initiation of folding at pH 5.5 55%  $\text{D}_2\text{O}$  (with a residual concentration of  $\text{GuHCl}$  of 0.37 M). Hence, we can be confident the closing rate associate with hydrogen bond formation during folding ( $> 50 \text{ sec}^{-1}$ ) is comfortably larger than the intrinsic exchange rate.

In these circumstances, the equilibrium constant for hydrogen-bond formation  $k_{c/o}$  is defined by the ration  $k_c/k_o$  which is equivalent to the protection factor (P) where  $P = k_{int}/k_{ex}$ . Having determined the equilibrium constant  $K_{(N/U)}$  by the denaturation method and assuming that all backbone amide protons are free to exchange in the unfolded state, it follows that

any regions of the molecule which have a protection factor (P) equal to  $K_{(NU)}$  can only exchange in the unfolded state. In other words, such measurements delineate sub-structures which are in a protected, hydrogen-bonded environment in any intermediate or partially folded state which is  
5 more stable than the unfolded chain.

To perform this study, the backbone amide protons were first assigned as described in the legend to figure 2 and the carbon chemical shifts show that the backbone conformation of the human protein is essentially the  
10 same as those of mouse<sup>9,10</sup> and hamster PrP<sup>C</sup><sup>11</sup>, consisting of three  $\alpha$ -helices and short distorted  $\beta$ -sheet (see figure 2b, figure 4).

When the molecule was subjected to hydrogen/deuterium exchange at pH 5.5 only 23 non-overlapping amide protons were protected to a  
15 measurable level in the experiment, ie with protection factors greater than 200 (see Figure 2a). These were located predominantly in the three helical segments of the structure which associate together to form the core of the molecule. Protection factors for these 23 residues show the stability of these sub-structures to be equivalent to the free energy change for  
20 unfolding of human PrP<sup>C</sup>. This type of behaviour resembles that of conventional proteins (eg barnase<sup>12</sup>, CI-2<sup>13</sup>, N-PGK<sup>14</sup> and Staphylococcal nuclease<sup>15</sup>) in that a subset of core residues can only exchange in the fully unfolded state. The only residues in these protected regions which are exceptional are those at or adjacent to the cysteine bridge. These have  
25 protection factors which are anomalously high, presumably owing to residual local structure in the unfolded state, a property which is consistent with the incomplete loss of CD signals in the denatured state.

The pattern of protection is so well correlated with the core structure of the native PrP<sup>C</sup> conformation that it is difficult to conceive of a grossly different topology, for instance one dominated by  $\beta$ -sheet, that would be consistent with this pattern. Hence, from these data, we conclude that

5 there are no structured species present, either folding intermediates or alternatively folded states, in which this three-helical core region is unfolded or significantly rearranged. If such species are present their combined population must be less than that of the unfolded state. In principle, this observation can be interpreted in one of two ways. Firstly,

10 if prion amyloid formation occurs by assembly of a partially folded intermediate then this intermediate must retain these  $\alpha$ -helical regions intact. Secondly, if the formation of amyloid states requires the disruption of this core structure, then the molecule must pass through a highly unfolded state before adopting an alternative fold capable of self-assembly.

15 Since, in all cases where secondary structure content has been assessed, the amyloid aggregate or amyloidogenic precursor states have been shown to be dominated by  $\beta$ -structure, the first mechanism appears improbable. Elimination of this route leads to the conclusion that complete or near-complete unfolding must precede rearrangement to the amyloidogenic

20 intermediate.

While it initially seems unlikely that complete disruption of the native fold is prerequisite for forming a misfolded, multimolecular state, there is a precedent for this type of behaviour. The N-terminal domain of the cell

25 surface receptor, CD2, forms interpenetrated dimers, trimers and tetramers which are misfolded forms of the normally monomeric state<sup>16</sup>. Experiments elucidating the folding pathway of the monomer show that it attains the native state via a topologically well-organised transient intermediate<sup>17</sup>. However, the degree of inter-penetration of the

polypeptide chain in these multimeric states means that the monomeric precursor must be much more unfolded than the transient intermediate.

Interestingly, in the case of amyloidogenic variants of lysozyme<sup>8</sup> it was  
5 proposed that fibril assembly occurred through the interaction of  
molecules that had the conformational properties of folding intermediates  
and that the mutations increased the population of these states, so  
promoting ordered aggregation. However, in the case of the prion  
diseases, in which native PrP<sup>C</sup> monomers are recruited into PrP<sup>Sc</sup> fibrils, it  
10 appears that the involvement of a folding intermediate or partially  
unfolded form is unlikely.

#### 6. *Digestion with proteinase K*

15

Prion protein is subjected to digestion with varying concentrations of  
proteinase K (BDH) at 37°C for 1 hr. Protein is digested at a  
concentration of 1m/ml in 10mM NaAcetate + 10mM Tris. Acetate pH  
8.0. Digestion is terminated by the addition of Pefablock (Boehringer  
20 Mannheim Corp.) to a final concentration of 1mM. Following the  
addition of Pefabloc samples are heated to 100°C for 5 mins in the  
presence of SDS loading buffer. Aliquots of 20µl are subjected to SDS-  
PAGE and the gels stained with Coomassie brilliant blue.

#### 25 7. *Antibody production methods*

Methods for purification of antigens and antibodies are described in  
Scopes, R.K. (1993) *Protein purification* 3rd Edition. Publisher -  
Springer Verlag. ISBN 0-387-94072-3 and 3-540-94072-3. The disclosure

of that reference, especially chapters 7 and 9, is incorporated herein by reference.

A monoclonal antibody which binds to a non-cellular form of a prion protein, namely PrP<sup>Sc</sup>, is disclosed by Korth *et al*, 1997 *Nature* 390, 74-77.

Methods of raising polyclonal and monoclonal antibodies to a non-cellular (PrP<sup>Sc</sup>) forms of prion proteins are described by Serban *et al*, (1990) *Neurology* 40, 110-117 and Kascsak *et al*, (1987) *J Virol* 61:12, 3688-3698.

The disclosures of the above documents are incorporated herein by reference.

The above and other methods can also be used to raise antibodies (polyclonal and monoclonal) to a non-cellular  $\beta$ -form of a prion protein which was described recently by Jackson *et al*, *Science* (March 1999) 283, pp 1935-1937.

Antibodies may be produced in a number of ways.

- 1 The prion protein or peptide is purified. The immunisation animal may be a "knock-out" mouse, with no prion protein at all. For monoclonal antibodies the animal is normally a mouse; for polyclonal, a rabbit or goat.
2. Raise antibodies to the antigen. For polyclonal antibodies, this is simply a matter of injecting suitably prepared sample into the animal at intervals, and testing its serum for the presence of antibodies (for



5 details, see Dunbar, B.S. & Schwoebel, E.D. (1990) Preparation of polyclonal antibodies. *Methods Enzymol.* 182, 663-670). But it is essential that the antigen (ie. the protein of interest) be as pure as possible. For monoclonal antibodies, the purity of the antigen is relatively unimportant if the screening procedure to detect suitable clones uses a bioassay.

Antibodies can also be produced by molecular biology techniques, with expression in bacterial or other heterologous host cells (Chiswell, D.J. & 10 McCafferty, J. (1992) Phage antibodies: will new "coli-clonal" antibodies replace monoclonal antibodies?" *Trends Biotechnol.* 10, 80-84). The purification method to be adopted will depend on the source material (serum, cell culture, bacterial expression culture, etc.) and the purpose of the purification (research, diagnostic investigation, commercial production). 15 The major methods are as follows:

1. *Ammonium sulphate precipitation.* The  $\gamma$ -globulins precipitate at a lower concentration than most other proteins, and a concentration of 33% saturation is sufficient. Either dissolve in 200g ammonium 20 sulphate per litre of serum, or add 0.5 vol of saturated ammonium sulphate. Stir for 30 minutes, then collect the  $\gamma$ -globulin fraction by centrifugation, redissolve in an appropriate buffer, and remove excess ammonium sulphate by dialysis or gel filtration.
- 25 2. *Polyethylene glycol precipitation.* The low solubility of  $\gamma$ -globulins can also be exploited using PEG. Add 0.1 vol of a 50% solution of PEG 6,000 to the serum, stir for 30 minutes and collect the  $\gamma$ -globulins by centrifugation. Redissolve the precipitate in an appropriate buffer, and remove excess PEG by gel filtration on a

column that fractionates in a range with a minimum around 6,000 Da.

3. *Isoelectric precipitation.* This is particularly suited for IgM molecules, and the precise conditions will depend on the exact properties of the antibody being produced.
4. *Ion-exchange chromatography.* Whereas most serum proteins have low isoelectric points,  $\gamma$ -globulins are isoelectric around neutrality, depending on the exact properties of the antibody being produced. Adsorption to cation exchangers in a buffer of around pH 6 has been used successfully, with elution with a salt gradient, or even standard saline solution to allow immediate therapeutic use.
5. *Hydrophobic chromatography.* The low solubility of  $\gamma$ -globulins reflects their relatively hydrophobic character. In the presence of sodium or ammonium sulphate, they bind to many hydrophobic adsorbents, such as "T-gel" which consists of  $\beta$ -mercaptoethanol coupled to divinyl sulphone-activated agarose.
6. *Affinity adsorbents.* *Staphylococcus aureus* Outer coat protein, known as Protein A, is isolated from the bacterial cells, and it interacts very specifically and strongly with the invariant region (F<sub>2</sub>) of immunoglobulins (Kessler, S.W. (1975) *Rapid isolation of antigens from cells with a staphylococcal protein A-antibody absorbent: Parameters of the interaction of antibody-antigen complexes with protein A. J Immunol.* 115, 1617-1624. Protein A has been cloned, and is available in many different forms, but the most useful is as an affinity column: Protein A coupled to agarose.

A mixture containing immunoglobulins is passed through the column, and only the immunoglobulins adsorb. Elution is carried out by lowering the pH; different types of IgG elute at different pHs, and so some trials will be needed each time. The differences in the immunoglobulins in this case are not due so much to the antibody specificity, but due to different types of F<sub>c</sub> region. Each animal species produces several forms of heavy chain varying in the F<sub>c</sub> region; for instance, mouse immunoglobulins include subclasses IgG<sub>1</sub>, IgG<sub>2a</sub>, and IgG<sub>2b</sub>, all of which behave differently on elution from Protein A.

Some  $\gamma$ -globulins do not bind well to Protein A. An alternative, Protein G from a *Streptococcus* sp., can be used. This is more satisfactory with immunoglobulins from farm animals such as sheep, goats and cattle, as well as with certain subclasses of mouse and rabbit IgGs.

The most specific affinity adsorbent is the antigen itself. The process of purifying an antibody on an antigen adsorbent is essentially the same as purifying the antigen on an antibody adsorbent. The antigen is coupled to the activated matrix, and the antibody-containing sample applied. Elution requires a process for weakening the antibody-antigen complex. This is particularly useful for purifying a specific antibody from a polyclonal mixture.

Monoclonal antibodies (MAbs) can be prepared to most antigens. The antigen-binding portion may be a part of an antibody (for example a Fab fragment) or a synthetic antibody fragment (for example a single chain Fv fragment [ScFv]). Suitable monoclonal antibodies to selected antigens may be prepared by known techniques, for example those disclosed in

"*Monoclonal Antibodies: A manual of techniques*", H Zola (CRC Press, 1988) and in "*Monoclonal Hybridoma Antibodies: Techniques and Applications*", J G R Hurrell (CRC Press, 1982).

- 5 Chimaeric antibodies are discussed by Neuberger *et al* (1988, *8th International Biotechnology Symposium Part 2*, 792-799).

Suitably prepared non-human antibodies can be "humanized" in known ways, for example by inserting the CDR regions of mouse antibodies into  
10 the framework of human antibodies.

The variable heavy ( $V_H$ ) and variable light ( $V_L$ ) domains of the antibody are involved in antigen recognition, a fact first recognised by early protease digestion experiments. Further confirmation was found by "humanisation"  
15 of rodent antibodies. Variable domains of rodent origin may be fused to constant domains of human origin such that the resultant antibody retains the antigenic specificity of the rodent parental antibody (Morrison *et al* (1984) *Proc. Natl. Acad. Sci. USA* 81, 6851-6855).

- 20 That antigenic specificity is conferred by variable domains and is independent of the constant domains is known from experiments involving the bacterial expression of antibody fragments, all containing one or more variable domains. These molecules include Fab-like molecules (Better *et al* (1988) *Science* 240, 1041); Fv molecules (Skerra *et al* (1988) *Science* 240,  
25 1038); single-chain Fv (ScFv) molecules where the  $V_H$  and  $V_L$  partner domains are linked via a flexible oligopeptide (Bird *et al* (1988) *Science* 242, 423; Huston *et al* (1988) *Proc. Natl. Acad. Sci. USA* 85, 5879) and single domain antibodies (dAbs) comprising isolated V domains (Ward *et al* (1989) *Nature* 341, 544). A general review of the techniques involved in

the synthesis of antibody fragments which retain their specific binding sites is to be found in Winter & Milstein (1991) *Nature* 349, 293-299.

By "ScFv molecules" we mean molecules wherein the  $V_H$  and  $V_L$  partner  
5 domains are linked via a flexible oligopeptide.

The advantages of using antibody fragments, rather than whole antibodies, are several-fold. The smaller size of the fragments may lead to improved pharmacological properties, such as better penetration of solid tissue.  
10 Effector functions of whole antibodies, such as complement binding, are removed. Fab, Fv, ScFv and dAb antibody fragments can all be expressed in and secreted from *E. coli*, thus allowing the facile production of large amounts of the said fragments.

15 Whole antibodies, and  $F(ab')_2$  fragments are "bivalent". By "bivalent" we mean that the said antibodies and  $F(ab')_2$  fragments have two antigen combining sites. In contrast, Fab, Fv, ScFv and dAb fragments are monovalent, having only one antigen combining sites.

20 A CDR-grafted antibody may be produced having at least one chain wherein the framework regions are predominantly derived from a first antibody (acceptor) and at least one CDR is derived from a second antibody (donor), the CDR-grafted antibody being capable of binding to the  $\beta$ -form PrP antigen.

25

The CDR-grafted chain may have two or all three CDRs derived from the donor antibody.

Advantageously, in the CDR-grafted chain, the or each CDR comprises a composite CDR comprising all the residues from the CDR and all the residues in the corresponding hypervariable region of the donor antibody.

- 5 Preferably, at least one residue in the framework regions of the CDR-grafted chain has been altered so that it corresponds to the equivalent residue in the antibody, and the framework regions of the CDR-grafted chain are derived from a human antibody.
- 10 Advantageously, the framework regions of the CDR-grafted chain are derived from a human Ig heavy chain. For such heavy chains, it is preferred that residue 35 in the heavy chain framework regions be altered so that it corresponds to the equivalent residue in the donor antibody.
- 15 Suitably, for such heavy chains, at least one composite CDR comprising residues 26 to 35, 50 to 65 or 95 to 102 respectively is grafted onto the human framework. It will be appreciated in this case that residue 35 will already correspond to the equivalent residue in the donor antibody.
- 20 Preferably, residues 23, 24 and 49 in such heavy chains correspond to the equivalent residues in the antibody. It is more preferred that residues 6, 23, 24, 48 and 49 in such heavy chains correspond to the donor antibody in equivalent residue positions. If desired, residues 71, 73 and 79 can also so correspond.
- 25 To further optimise affinity, any one or any combination of residues 57, 58, 60, 88 and 91 may correspond to the equivalent residue in the donor antibody.

The heavy chain may be derived from the human KOL heavy chain. However, it may also be derived from the human NEWM or EU heavy chain.

- 5 Alternatively, the framework regions of the CDR-grafted chain may be derived from a human kappa or lambda light chain. For such a light chain, advantageously at least one composite CDR comprising residues 24 to 34, 50 to 56 or 89 to 97 respectively is grafted onto the human framework. Preferably, residue 49 also corresponds to the equivalent residue in the  
10 donor antibody.

To further optimise affinity, it is preferable to ensure that residues 49 and 89 correspond to the equivalent residues in the donor antibody. It may also be desirable to select equivalent donor residues that form salt bridges.

15

The light chain is preferably derived from the human REI light chain. However, it may also be derived from the human EU light chain.

- Preferably, the CDR-grafted antibody comprises a light chain and a heavy  
20 chain, one or, preferably, both of which have been CDR-grafted in accordance with the principles set out above for the individual light and heavy chains.

- It is advantageous that all three CDRs on the heavy chain are altered and  
25 that minimal alteration is made to the light chain. It may be possible to alter none, one or two of the light chain CDRs and still retain binding affinity at a reasonable level.

It will be appreciated that in some cases, for both heavy and light chains, the donor and acceptor residues may be identical at a particular position and thus no change of acceptor framework residue will be required.

- 5 It will also be appreciated that in order to retain as far as possible the human nature of the CDR-grafted antibody, as few residue changes as possible should be made. It is envisaged that in many cases, it will not be necessary to change more than the CDRs and a small number of framework residues. Only in exceptional cases will it be necessary to change a larger number of  
10 framework residues.

Preferably, the CDR-grafted antibody is a complete Ig, for example of isotype IgG<sub>1</sub>, or IgG<sub>2</sub>, IgG<sub>3</sub> or IgM.

- 15 If desired, one or more residues in the constant domains of the Ig may be altered in order to alter the effector functions of the constant domains.

Preferably, the CDR-grafted antibody has an affinity for the  $\beta$ -form PrP antigen of between about  $10^5 \cdot M^{-1}$  to about  $10^{12} \cdot M^{-1}$ , more preferably at least  
20  $10^8 \cdot M^{-1}$ .

Advantageously, the or each CDR is derived from a mammalian antibody and preferably is derived from a murine MAb.

- 25 Suitably, the CDR-grafted antibody is produced by use of recombinant DNA technology.

A further method for producing a CDR-grafted antibody comprises providing a first DNA sequence, encoding a first antibody chain in which



the framework regions are predominantly derived from a first antibody (acceptor) and at least one CDR is derived from a second antibody (acceptor), under the control of suitable upstream and downstream elements; transforming a host cell with the first DNA sequence; and culturing the  
5 transformed host cell so that a CDR-grafted antibody is produced.

Preferably, the method further comprises: providing a second DNA sequence, encoding a second antibody chain complementary to the first chain, under the control of suitable upstream and downstream elements; and  
10 transforming the host cell with both the first and second DNA sequences.

Advantageously, the second DNA sequence encodes a second antibody chain in which the framework regions are predominantly derived from a first antibody (acceptor) and at least one CDR is derived from the second  
15 antibody (donor).

The first and second DNA sequences may be present on the same vector. In this case, the sequences may be under the control of the same or different upstream and/or downstream elements.

20

Alternatively, the first and second DNA sequences may be present on different vectors.

A nucleotide sequence may be formed which encodes an antibody chain in  
25 which the framework regions are predominantly derived from a first antibody (acceptor) and at least one CDR is derived from a second antibody (donor), the antibody chain being capable of forming a CDR-grafted antibody.

The CDR-grafted antibodies may be produced by a variety of techniques, with expression in transfected cells, such as yeast, insect, CHO or myeloma cells, being preferred. Most preferably, the host cell is a CHO host cell.

- 5 To design a CDR-grafted antibody, it is first necessary to ascertain the variable domain sequence of an antibody having the desired binding properties. Suitable source cells for such DNA sequences include avian, mammalian or other vertebrate sources such as chickens, mice, rats and rabbits, and preferably mice. The variable domain sequences ( $V_H$  and  $V_L$ )  
10 may be determined from heavy and light chain cDNA, synthesized from the respective mRNA by techniques generally known to the art. The hypervariable regions may then be determined using the Kabat method (Wu and Kabat, J. (1970) *J. Exp. Med.* 132, 211). The CDRs may be determined by structural analysis using X-ray crystallography or molecular  
15 modelling techniques. A composite CDR may then be defined as containing all the residues in one CDR and all the residues in the corresponding hypervariable region. These composite CDRs along with certain select residues from the framework region are preferably transferred as the "antigen binding sites", while the remainder of the antibody, such as the  
20 heavy and light chain constant domains and remaining framework regions, may be based on human antibodies of different classes. Constant domains may be selected to have desired effector functions appropriate to the intended use of the antibody so constructed. For example, human IgG isotypes, IgG<sub>1</sub> and IgG<sub>3</sub>, are effective for complement fixation and cell  
25 mediated lysis. For other purposes other isotypes, such as IgG<sub>2</sub> and IgG<sub>4</sub>, or other classes, such as IgM and IgE, may be more suitable.

For human therapy, it is particularly desirable to use human isotypes, to minimise antiglobulin responses during therapy. Human constant domain

DNA sequences, preferably in conjunction with their variable domain framework bases can be prepared in accordance with well-known procedures. An example of this is CAMPATH 1H available from Glaxo Wellcome.

5

Certain CDR-grafted antibodies are provided which contain select alterations to the human-like framework region (in other words, outside of the CDRs of the variable domains), resulting in a CDR-grafted antibody with satisfactory binding affinity. Such binding affinity is preferably from  
10 about  $10^5 \cdot M^{-1}$  to about  $10^{12} \cdot M^{-1}$  and is more preferably at least about  $10^8 \cdot M^{-1}$ .

In constructing the CDR-grafted antibodies, the  $V_H$  and/or  $V_L$  gene segments may be altered by mutagenesis. One skilled in the art will also  
15 understand that various other nucleotides coding for amino acid residues or sequences contained in the Fc portion or other areas of the antibody may be altered in like manner (see, for example, PCT/US89/00297).

Exemplary techniques include the addition, deletion or nonconservative  
20 substitution of a limited number of various nucleotides or the conservative substitution of many nucleotides, provided that the proper reading frame is maintained.

Substitutions, deletions, insertions or any subcombination may be used to  
25 arrive at a final construct. Since there are 64 possible codon sequences but only twenty known amino acids, the genetic code is degenerate in the sense that different codons may yield the same amino acid. Thus there is at least one codon for each amino acid, ie each codon yields a single amino acid and no other. It will be apparent that during translation, the proper reading

frame must be maintained in order to obtain the proper amino acid sequence in the polypeptide ultimately produced.

5 Techniques for additions, deletions or substitutions at predetermined amino acid sites having a known sequence are well known. Exemplary techniques include oligonucleotide-mediated site-directed mutagenesis and the polymerase chain reaction.

10 Oligonucleotide site-directed mutagenesis in essence involves hybridizing an oligonucleotide coding for a desired mutation with a single strand of DNA containing the region to be mutated and using the single strand as a template for extension of the oligonucleotide to produce a strand containing the mutation. This technique, in various forms, is described in Zoller and Smith (1982) *Nucl. Acids Res.* 10, 6487.

15

#### 8. *Raising an antibody response in a patient*

Active immunisation of the patient is preferred. In this approach, one or more PrP proteins or peptides are prepared in an immunogenic formulation  
20 containing suitable adjuvants and carriers and administered to the patient. Suitable adjuvants include Freund's complete or incomplete adjuvant, muramyl dipeptide, the "Iscoms" of EP 109 942, EP 180 564 and EP 231 039, aluminium hydroxide, saponin, DEAE-dextran, neutral oils (such as miglyol), vegetable oils (such as arachis oil), liposomes, Pluronic polyols or  
25 the Ribi adjuvant system (see, for example GB-A-2 189 141). "Pluronic" is a Registered Trade Mark.

Skilled persons will appreciate that purification of the cellular form and/or cellular-form binding agents, especially antibodies, can be accomplished

by conventional techniques such as affinity chromatography. By "cellular form binding agent" we include any agent which is able to binds preferentially the cellular form rather than the non-cellular form of a prion protein. The binding agent is preferably an antibody or antigen binding  
5 fragment thereof such a Fab, Fv, ScFv and Ab, but it may also be any other ligand which exhibits the preferential binding characteristic mentioned above.

Affinity chromatography is described in Scopes, R. K. (1993) *Protein*  
10 *Purification: principles and practice* 3<sup>rd</sup> Ed. Springer-Verlag, New York, ISBN 0-387-44072-3, 3-540-94072-3. (See chapters 7 and 9 in particular).

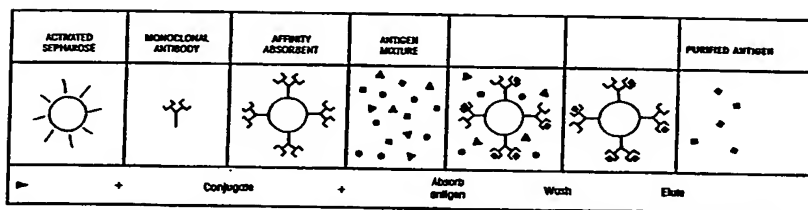
Further information on the above affinity chromatography techniques and  
15 the immunoassay of antigen and antibody is provided by Roitt (1991) *Essential Immunology* 7<sup>th</sup> Ed. Blackwell Scientific Publications, London, ISBN 0-632-02877-7 (see chapter 5 in particular).

The disclosure of the above references is incorporated herein by reference.  
20 Nevertheless, an the outline of known methods is described herein.

#### *Purification of antigens and antibodies by affinity chromatography*

Antigen or antibody is bound through its free amino groups to cyanogen-  
25 bromide-activated Sepharose particles. Insolubilized antibody, for example, can be used to pull the corresponding antigen out of solution in which it is present as one component of a complex mixture, by absorption to its surface. The unwanted material is washed away and the required ligand released from the affinity absorbent by disruption of the

- antigen-antibody bonds by changing the pH or adding chaotropic ions such as thiocyanate. Likewise, an antigen immunosorbent can be used to absorb out an antibody from a mixture whence it can be purified by elution. The potentially damaging effect of the eluting agent can be avoided by running the anti-serum down an affinity column so prepared as to have relatively weak binding for the antibody being purified; under these circumstances, the antibody is retarded in flow rate rather than being firmly bound. If a protein mixture is separated by iso-electric focusing into discrete bands, an individual band can be used to affinity purify specific antibodies from a polyclonal antiserum.



*Affinity chromatography. A column is filled with Sepharose-linked antibody. The antigen mixture is poured down the column. Only the antigen binds and is released by*

*change in pH for example. An antigen-linked affinity column will purify antibody obviously.*

### 15 *Immunoassay of antigen and antibody with labelled reagents*

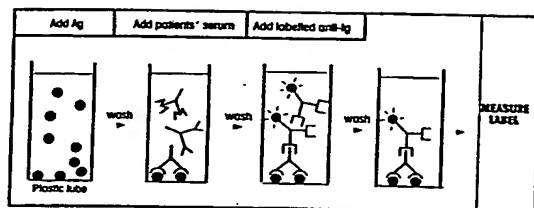
- Antigen and antibody can be used for the detection of each other and a variety of immunoassay techniques have been developed in which the final read-out of the reaction involves a reagent conjugated with an appropriate label. Radiolabelling with  $^{131}\text{I}$ ,  $^{125}\text{I}$ , is an established technique.

*Soluble Phase immunoassays**radioimmunoassay (RIA) for antigen*

- 5 The binding of radioactively labelled antigen to a limited fixed amount of antibody can be partially inhibited by addition of unlabelled antigen and the extent of this inhibition can be used as a measure of the unlabelled material added.

10 *For antibody*

- The antibody content of a serum can be assessed by the ability to bind to antigen which has been in and immobilised by physical absorption to a plastic tube or micro-agglutination tray with multiple wells; the bound  
15 immunoglobulin may then be estimated by addition of a labelled anti-Ig raised for another species. For example, a patient's serum is added to a microwell coated with antigen, the antibodies will bind to the plastic and remaining serum proteins can be readily washed away. Bound antibody can be estimated by addition of  $^{125}\text{I}$ -labelled purified rabbit anti IgG; after  
20 rinsing out excess unbound reagent, the radioactivity of the tube will be a measure of the antibody content of the patient's serum. The distribution of antibody in different classes can obviously be determined by using specific antisera.

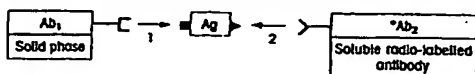


*Solid phase immunoassay for antibody. By attaching antibody to the solid phase, the system can be used to assign antigen. To reduce non-specific binding of IgG to the solid phase after absorption of the first reagent, it is usual to add an irrelevant protein such as gelatin, or more recently  $\alpha_2$  glycoprotein, to block any free sites on the plastic*

### *Immunoradiometric assay for antigen*

5

This differs from radioimmunoassay in the sense that the labelled reagent is used in excess. For the estimation of antigen, antibodies are coated on to a solid surface such as plastic and the test antigen solution added; after washing, the amount of antigen bound to the plastic can be estimated by adding an excess of radio-labelled antibody. The specificity of the method can be improved by the sandwich assay which uses solid phase and labelled antibodies with specificities for different parts of the antigen:



Because of health hazards and the deterioration of reagents through radiation damage, types of label other than radiosotopes have been sought.

### *ELISA (enzyme-linked immunosorbent assay)*

Perhaps the most widespread alternative has been the use of enzymes which give a coloured reaction product, usually in solid phase assays. Enzymes such as horse radish peroxidase and phosphatase have been widely employed. A way of amplifying the phosphatase reaction is to use



NADP as a substrate to generate NAD which now acts as a coenzyme for a second enzyme system. Pyrophosphatase from *E.coli* provides a good conjugate because the enzyme is not present in tissues, is stable and gives a good reaction colour. Chemi-luminescent systems based on enzymes  
5 such as luciferase can also be used.

Conjugation with the vitamin biotin is frequently used since this can readily be detected by its reaction with enzyme-linked avidin or streptavidin to which it binds with great specificity and affinity.

10

#### *Identification of ligands by phage display*

The display of proteins and polypeptides on the surface of bacteriophage (phage), fused to one of the phage coat proteins, provides a powerful tool  
15 for the selection of specific ligands. This 'phage display' technique was originally used by Smith (*Science* 1985, 228, 1315-7) to create large libraries of antibodies for the purpose of selecting those with high affinity for a particular antigen. More recently, the method has been employed to present peptides, domains of proteins and intact proteins at the surface of  
20 phages in order to identify ligands having desired properties.

The principles behind phage display technology are as follows:

- (i) Nucleic acid encoding the protein or polypeptide for display is cloned  
25 into a phage;
- (ii) The cloned nucleic acid is expressed fused to the coat-anchoring part of one of the phage coat proteins (typically the p3 or p8 coat proteins in the case of filamentous phage), such that the foreign protein or polypeptide is displayed on the surface of the phage;

(iii) The phage displaying the protein or polypeptide with the desired properties is then selected (*e.g.* by affinity chromatography) thereby providing a genotype (linked to a phenotype) that can be sequenced, multiplied and transferred to other expression systems.

5

Alternatively, the foreign protein or polypeptide may be expressed using a phagemid vector (*i.e.* a vector comprising origins of replication derived from a phage and a plasmid) that can be packaged as a single stranded nucleic acid in a bacteriophage coat. When phagemid vectors are employed, a "helper phage" is used to supply the functions of replication and packaging of the phagemid nucleic acid. The resulting phage will express both the wild type coat protein (encoded by the helper phage) and the modified coat protein (encoded by the phagemid), whereas only the modified coat protein is expressed when a phage vector is used.

15

Methods of selecting phage expressing a protein or peptide with a desired specificity are known in the art. For example, a widely used method is "panning", in which phage stocks displaying ligands are exposed to solid phase coupled target molecules, *e.g.* using affinity chromatography.

20

Alternative methods of selecting phage of interest include SAP (Selection and Amplification of Phages; as described in WO 95/16027) and SIP (Selectively-Infective Phage; EP 614989A, WO 99/07842), which employ selection based on the amplification of phages in which the displayed ligand specifically binds to a ligand binder. In one embodiment of the SAP method, this is achieved by using non-infectious phage and connecting the ligand binder of interest to the N-terminal part of p3. Thus, if the ligand binder specifically binds to the displayed ligand, the otherwise non-infective ligand-expressing phage is provided with the parts

25

of p3 needed for infection. Since this interaction is reversible, selection can then be based on kinetic parameters (see Duenas *et al.*, 1996, *Mol. Immunol.* 33, 279-285).

- 5 The use of phage display to isolate ligands that bind biologically relevant molecules has been reviewed in Felici *et al.* (1995) *Biotechnol. Annual Rev.* 1, 149-183, Katz (1997) *Annual Rev. Biophys. Biomol. Struct.* 26, 27-45 and Hoogenboom *et al.* (1998) *Immunotechnology* 4(1), 1-20. Several randomised combinatorial peptide libraries have been constructed
- 10 to select for polypeptides that bind different targets, *e.g.* cell surface receptors or DNA (reviewed by Kay, 1995, *Perspect. Drug Discovery Des.* 2, 251-268; Kay and Paul, 1996, *Mol. Divers.* 1, 139-140). Proteins and multimeric proteins have been successfully phage-displayed as functional molecules (see EP 0349578A, EP 0527839A, EP 0589877A;
- 15 Chiswell and McCafferty, 1992, *Trends Biotechnol.* 10, 80-84). In addition, functional antibody fragments (*e.g.* Fab, single chain Fv [scFv]) have been expressed (McCafferty *et al.*, 1990, *Nature* 348, 552-554; Barbas *et al.*, 1991, *Proc. Natl. Acad. Sci. USA* 88, 7978-7982; Clackson *et al.*, 1991, *Nature* 352, 624-628), and some of the shortcomings of
- 20 human monoclonal antibody technology have been superseded since human high affinity antibody fragments have been isolated (Marks *et al.*, 1991, *J. Mol. Biol.* 222, 581-597; Hoogenboom and Winter, 1992, *J. Mol. Biol.* 227, 381-388).

25 9. *Immunisation - Preferred protocols*

*Preparation of antigen*

For the preparation of monoclonal antibodies (mAbs), PrP or its peptide derivatives may be provided in an acetate buffer as described above. Antigens may be physically (by creating recombinant PrP fusion proteins) or chemically coupled to suitable carrier proteins to provide additional T cell help for immunisation in PRNP <sup>+/+</sup> mice and other rodents.

Mice of various strains, rats, hamsters or rabbits can be inoculated subcutaneously with PrP (50-100 µg/ animal), emulsified in complete/incomplete Freund's adjuvant at 3 weekly intervals (Days 0,20,41). At day 37 anti-peptide activity can be assayed by ELISA. On day 48 in the case of animals used for mAb production, a final intraperitoneal boost can be given and the animals killed for fusion 3 days later (day 50). In the case of rabbits inoculated to produce polyclonal antibodies, the animals may be bled after the final boost, and at regular subsequent intervals with or without further inoculation depending on anti-PrP titre.

#### 10. *Monoclonal antibody preparation*

Routine methods may be used (Galfre G., and Milstein, C. 1981 *Methods in Enzymology* 73, 3-46)

#### *Myeloma cells*

The following fusion partners may be used:

5	Mouse	NSO/u	Clark M.R., and Milstein, C. 1982 <i>Somatic Cells Genetics</i> 7, 657-666
		X63/Ag 8.653	Keranev <i>et al.</i> 1979 <i>J. Immunol.</i> 123, 1548-1550
		SP2/0	Sanchez-Madrid <i>et al</i> 1983 <i>J. Immunol</i> 130, 309-312
			Bluestone 1987 <i>PNAS</i> 84, 1374
10	Rat fusions	Y3 (210.RCY3.Ag 1.2.3)YO	Galfre G., and Milstein, C. 1981 <i>Methods in Enzymology</i> 73, 3-46
	Hamster fusions	SP2/0	

### *Fusion procedure*

15

20

25

30

Two spleens from mice that have produced high titre antibody are fused. Myeloma cells growing in exponential phase may be mixed with splenic single cell suspensions in appropriate ratios, washed free of serum, and then gently resuspended in a 50% polyethylene glycol solution at 37°C followed after 1-2 minutes with increasing volumes of serum-free medium. After a further incubation in RPMI/10% foetal calf serum (RF<sub>10</sub>) at 37°C for 30 minutes, the hybridomas may be washed and resuspended in HAT medium and hybridoma growth supplements, are cultured in 200 µl flat-bottomed tissue culture wells at 37°C in 5% CO<sub>2</sub> enriched humidified air. The cultures remain in RF10/HAT medium for 2 weeks, and are then maintained in RF<sub>10</sub>/HT medium for a further week and thereafter in RF10. At day 10-14 positive wells are screened for anti-PrP antibody by ELISA. Positive wells are then repeatedly cloned by limiting dilution until stable. Hybridomas cryopreserved in FCS 10% DMSO are stored in liquid N<sub>2</sub> dewars.

### 11. Screening for anti-PrP antibodies in serum

Recombinant PrP (0.5-10 $\mu$ g/well), may be dialysed against appropriate  
5 coating buffer (pH 4-10) and adsorbed to standard ELISA plates for 30-60  
minutes at 37°C prior to washing x4 in PBS/Tween 0.05% (PBST). After  
blocking in PBS/BSA 2% with or without additional sera, dilutions of  
serum are incubated in duplicate as are relevant negative and positive  
10 controls. After washing, the peroxidase conjugated anti-IgG secondary is  
incubated, washed and then fresh ortho-phenyl diamine (OPD) substrate  
added. Finally after stopping the reaction with 3M sulphuric acid the  
absorbance is measured at 492nm.

### 12. Screening culture supernatants for PrP<sup>Sc</sup>-specific monoclonal 15 antibodies

This may involve a staged two day procedure. On day 1, 50 $\mu$ l of the  
growing cultures may be screened for anti-PrP IgG as in the ELISA  
described above. This PrP may or may not be first digested with  
20 proteinase K to remove any PrP species. Positive wells in this assay may  
then be screened the following day in a dot blot assay modified from *Sidle  
et al* 1995. Dot blot apparatus (ELIFA, Pierce Wariner) can be used that  
allows the simultaneous screening of multiple supernatants. Supernatants  
can be screened for binding to recombinant  $\beta$ -PrP, 1% normal human  
25 brain homogenate and to a pool of 1% homogenates from CJD brains  
containing types 1-4, thus enabling the preferential selection of PrP<sup>Sc</sup>-  
specific mAbs. Thus only mAbs that bind infectious prions and not PrP<sup>c</sup>  
from normal brain will be expanded. Alternatively, culture supernatants  
can be screened for preferential binding to either cellular or  $\beta$ -PrP, or to

synthetic peptides to which PrP<sup>Sc</sup>-specific mAbs may bind. The 15B3 PrP<sup>Sc</sup>-specific mAb cross-reacts with human, bovine and murine PrP<sup>Sc</sup>, and its epitope has been mapped with linear synthetic peptides to three regions on the bovine PrP molecule: residues 142-148, 162-170 and 214-226 and later two of which may not be recognised by antibodies that bind to both PrP<sup>C</sup> and PrP<sup>Sc</sup> (Korth C. *et al.* 1997 *Nature* 390, 74-77). These peptides are absorbed to ELISA plates with poly-lysine.

### 13. *Characterisation of mAbs*

10

Immunoglobulin subclass and culture supernatant Ig concentration can be measured by standard ELISA techniques. The fine specificity of PrP<sup>C</sup> or PrP<sup>Sc</sup> specific mAbs can be defined either by using a gridded array of overlapping human PrP peptides (synthesised commercially by Jerino Bio Tools GmbH) or by using pools of PrP synthetic peptides (synthesised individually using standard f-moc chemistry) in the standard ELISA. Measurements of the affinity of anti-PrP mAbs for their ligands can be made using surface plasmon resonance. Direct comparisons can be made of mAb binding to cellular and non-cellular-PrP molecules.

20

### 14. *Binding of mAbs to surface bound and intracellular PrP*

Flow cytometry and immunofluorescence microscopy may be used to study surface and intracellular PrP<sup>C</sup>/PrP<sup>Sc</sup> expression in cell lines that express surface PrP (eg EVBV lymphoblastoid, U937, K562, HEL) and peripheral blood mononuclear cells.

25

### 15. *Binding to PrP in tissue sections*

Both acetone fixed fresh frozen sections and fixed paraffin embedded sections from normal and CJD/BSE/scrapie tissue can be used to assess  
5 the usefulness of PrP binding mAbs in routine immunohistochemistry.

### 16. *Use of antibody in the diagnosis of a prion disease*

The detection of the disease-associated isoform of prion protein, PrP<sup>Sc</sup>, in  
10 brain or other tissues from patients is thought to be diagnostic of prion disease. To distinguish PrP<sup>Sc</sup> from its cellular precursor, PrP<sup>C</sup>, requires either pre-treatment with proteinase K, which will completely digest PrP<sup>C</sup>, but only removes a protease-sensitive N-terminal of PrP<sup>Sc</sup> or, alternatively, would require an antibody which distinguished between  
15 PrP<sup>C</sup> and PrP<sup>Sc</sup>. Only one such selective antibody (Korth C. *et al.* 1997 *Nature* 390, 74-77) has yet been reported and appears to be able to selectively immunoprecipitate PrP<sup>Sc</sup>. It is not clear as yet, however, whether this antibody offers any increase in diagnostic sensitivity over existing monoclonals. It is an IgM antibody and is likely to be of low  
20 affinity for PrP<sup>Sc</sup>.

The PrP<sup>C</sup> specific binding agents, especially antibodies of the invention provide an important means distinguishing PrP<sup>Sc</sup> from PrP<sup>C</sup>.

25 Many detection systems are available for using a monoclonal antibody to diagnose a disease. A number of possibilities are discussed below:

### 17. *Detection of PrP<sup>Sc</sup> in body fluids or tissue homogenates*



a. Sandwich ELISA can be used to detect PrP<sup>Sc</sup> in body fluids eg serum or cerebrospinal fluid (CSF). This relies on using immobilised PrP<sup>Sc</sup>-specific mAbs to capture PrP<sup>Sc</sup> in solution and then using biotinylated mAbs or rabbit polyclonal antiserum with specificity for alternative PrP epitopes to detect the immobilised complexes. The same techniques can be used to detect PrP<sup>Sc</sup> in tissue homogenates. The PrP<sup>C</sup> binding agents of the invention can be used in a sample pretreatment step to increase the sensitivity of such PrP<sup>Sc</sup> assays. They also allow PrP<sup>Sc</sup> binding agents which are not specific for PrP<sup>Sc</sup> to be used in the subsequent detection step.

b. Dot blots may be used. Here tissue homogenates are placed directly on a suitable membrane and be treated with PrP<sup>C</sup> specific binding agent of the invention to remove PrP<sup>C</sup>. The membrane can be incubated with anti-PrP antibodies and then such binding detected using an appropriate, labelled secondary antibody. Various labelling systems, involving enzymatic, fluorescent, radioisotopic or chemiluminescent methods are commonly used.

c. Standard Western blotting techniques can be used. These methods allow not only the detection of PrP, but of specific patterns of banding following proteinase K digestion. These patterns allow the recognition of distinct strains of prions and allow, for instance, the differentiation of new variant CJD from classical CJD (see Collinge *et al.* 1996 *Nature* 383, 685-690 and international PCT patent application published as WO 98/16834).

d. Diagnostic methods may be developed based on the differential affinity of anti-PrP mAbs for PrP<sup>C</sup> and PrP<sup>Sc</sup>. Surface

plasmon resonance is ideally suited for this purpose. In such assays, purified anti-PrP mAbs are immobilised and binding to solubilised PrP measured directly from tissue fluids and homogenates. Enrichment of PrP<sup>Sc</sup> by differential centrifugation or  
5 affinity purification or pretreatment with PrP<sup>C</sup> specific binding agents of the invention may be useful prior to the above assays.

#### 18. *Using PrP<sup>C</sup> specific monoclonal antibodies*

10 This may involve a staged two day procedure. On day 1, 50 $\mu$ l of the growing cultures may be screened for antibodies to a non-cellular form of PrP eg anti- $\beta$  PrP IgG as in the ELISA described above. This  $\beta$ -PrP may or may not be first treated with the PrP<sup>C</sup> specific antibodies of the invention to remove any cellular form PrP<sup>C</sup>, species. Positive wells in this  
15 assay may then be screened the following day in a dot blot assay modified from Collinge et al 1995 *Lancet* 346:569-570. Dot blot apparatus (ELIFA, Pierce Wariner) can be used that allows the simultaneous screening of multiple supernatants. Supernatants can be screened for binding to recombinant  $\beta$ -PrP, 1% normal human brain homogenate and  
20 to a pool of 1% homogenates from CJD brains containing types 1-4, thus enabling the preferential selection of PrP<sup>Sc</sup>-specific mAbs. Thus only mAbs that bind infectious prions and not PrP<sup>C</sup> from normal brain will be expanded. Alternatively, culture supernatants can be screened for preferential binding to either cellular from or non-cellular  $\beta$ -PrP, or to  
25 synthetic peptides to which PrP<sup>Sc</sup>-specific mAbs may bind. The 15B3 PrP<sup>Sc</sup>-specific mAb cross-reacts with human, bovine and murine PrP<sup>Sc</sup>, and its epitope has been mapped with linear synthetic peptides to three regions on the bovine PrP molecule: residues 142-148, 162-170 and 214-226 and later two of which may not be recognised by antibodies that bind

to both PrP<sup>C</sup> and PrP<sup>Sc</sup> (Korth C. *et al.* 1997 *Nature* 390, 74-77). These peptides are adsorbed to ELISA plates with poly-lysine.

**19. Detection of cell associated PrP<sup>Sc</sup>**

5

It is likely that the levels of PrP<sup>Sc</sup> in peripheral blood mononuclear cells (PBMC) of vCJD patients will be low and detection will depend on optimising methods for surface and intracellular detection of PrP and then identifying lymphocyte sub-populations with the highest prion load. Anti-

- 10 PrP mAbs can be purified and conjugated to biotin of fluorochromes for this purpose. Dual and three colour flow cytometry can be used to identify the PrP<sup>Sc</sup> bearing cell types. After surface staining by conventional techniques, intracellular PrP can be detected after fixation and permeabilisation of the cell membranes. Cellular manipulation (eg
- 15 stimulation of proliferation of the pharmacological blockade of intracellular secretory or endocytic pathways) may be used to enhance PrP detection. The PrP<sup>C</sup> specific binding agents of the invention may be used to increase the sensitivity of the above methods.

## 20. *Immunohistochemistry*

Prion disease may be diagnosed by abnormal patterns of PrP immunoreactivity on either formalin fixed, or frozen, tissue sections using  
5 established immunohistochemical detection techniques. Frozen tissue sections of whole brains (histoblots) may be treated with proteinase K or the PrP<sup>C</sup> specific binding agents of the invention and similarly exposed to antibodies to detect patterns of PrP<sup>Sc</sup> deposition which may also allow discrimination of prion strain types.

10

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## CLAIMS:

1. A peptide consisting of all or a fragment or variant of an amino  
5 acid sequence of a prion protein which exhibits stability when measured  
by hydrogen/deuterium amide exchange at pH 5.5.
2. A peptide as claimed in Claim 1, wherein the peptide exhibits a  
protection factor greater than the equilibrium constant between a native  
10 state and an unfolded state; the protection factor ( $K_{ex}/K_{im}$ ) being  
determined by calculating amide exchange rate constants ( $K_{ex}$  from a  
series  $^1H$ - $^{15}N$  HSQC spectra and using intrinsic amide exchange rates  
( $K_{im}$ ).
- 15 3. A peptide as claimed in Claims 1 or 2, consisting of all or a  
fragment or variant of an amino acid sequence from residue number 176  
to 221 of one of the prion protein cellular form (PrP<sup>C</sup>) sequences shown in  
figure 5.
- 20 4. A peptide as claimed in Claim 3, consisting of all or a fragment or  
variant of an amino acid sequence from residue number 179 to 218 of any  
one of the said PrP<sup>C</sup> sequences.
5. A peptide, consisting of all, or a fragment or variant of an amino  
25 acid sequence of approximately ten residues which flank the disulphide  
bond between Cys 179 and Cys 214 in one of the PrP<sup>C</sup> sequences shown in  
figure 5.



6. A method of making an antibody comprising administering a cellular form (PrP<sup>c</sup>) of a prion protein or a peptide as claimed in any one of Claims 1 to 5 to an animal so as to generate an antibody response and collecting the antibody therefrom.

5

7. An antibody obtainable by a method as claimed in Claim 6; which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.

10 8. An antibody which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.

9. A method of making a monoclonal antibody comprising administering a cellular form (PrP<sup>c</sup>) of a prion protein or a peptide as  
15 claimed in any one of Claims 1 to 5 to an animal so as to generate an antibody response; subsequently fusing an antibody producing cell from the animal with a myeloma cell to form a hybridoma and obtaining a monoclonal antibody produced by the hybridoma.

20 10. A monoclonal antibody obtainable by a method as claimed in Claim 9 which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.

11. A monoclonal antibody which binds preferentially to a cellular form  
25 of a prion protein rather than a non-cellular form.

12. A method of making a binding agent capable of binding to a cellular form of a prion protein comprising exposing a peptide as claimed

in any one of Claims 1 to 5 to a sample whereby any binding agent can bind the peptide and collecting the binding agent so bound.

13. A method as claimed in Claim 12 wherein the binding agent is an  
5 antibody.

14. A binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form.

10 15. A binding agent as claimed in Claim 14 which is obtainable by the method of Claim 12.

16. Use of an antibody or binding agent as claimed in any one of Claims 7, 10, 11, 14 or 15 in a method of detecting a cellular form of a  
15 prion protein comprising exposing a sample to the antibody or binding agent and detecting binding of the antibody or binding agent to the cellular form of a prion protein.

17. Use of an antibody or binding agent as claimed in any one of  
20 Claims 7, 10, 11, 14 or 15 in a method of detecting a non-cellular form of a prion protein comprising a first step of exposing a sample to the antibody or binding agent; a second step of exposing the sample to an agent which binds the non-cellular form of a prion protein; and detecting binding of the agent to the non-cellular form.

25

18. Use as claimed in Claim 17 wherein the antibody or binding agent which has bound the cellular form is separated from the sample prior to the second step.

19. Use as claimed in Claim 17 or 18 wherein the antibody or binding agent in the first and/or second step is immobilised.

20. A method of removing a cellular form of a prion protein from a sample comprising exposing the sample to an antibody or binding agent as claimed in any one of Claims 7, 10, 11, 14 or 15 and separating the sample from the antibody or binding agent which has bound the cellular form.

21. A method or use as claimed in any one of Claims 12, 13, 16 to 20 wherein the sample consists of or comprises a bodily fluid or tissue.

22. A method as claimed in Claim 21 wherein the sample is selected from one or more of blood, or a component thereof such as plasma; cerebrospinal fluid; lymph; faeces; urine; sputum; tissue from a lymph node, appendix, tonsil and spleen.

23. A method as claimed in any one of Claims 16 to 22 for use in medicine, preferably in the prevention, treatment and/or diagnosis of a prion disease.

24. A method as claimed in Claim 23 wherein the method is for use in the diagnosis of the presence of a prion disease or a predisposition to such a disease.

25. A kit comprising means for carrying out the methods of any one of Claims 16 to 24.

26. An antibody or binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form of a prion protein, for use in medicine, preferably in the prevention, treatment and/or diagnosis of a prion disease.

5

27. A peptide sequence of a cellular form of a prion protein which exhibits stability when measured by hydrogen/deuterium amide exchange at pH 5.5, substantially as described herein with reference to one or more of the methods and/or accompanying figures.

10

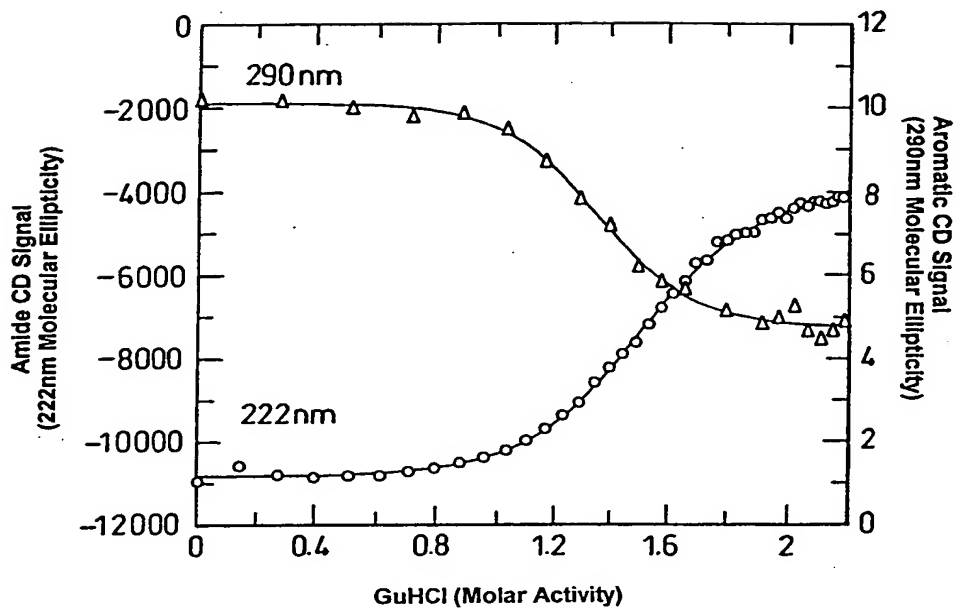
28. An antibody or binding agent which binds preferentially to a cellular form of a prion protein rather than a non-cellular form, substantially as described herein with reference to one or more of the methods and accompanying figures.

15

29. A method of using an antibody and/or binding agent as claimed in Claim 28, the method being substantially as described herein with reference to one or more of the examples and accompanying figures.

20 30. Any novel subject-matter disclosed herein.

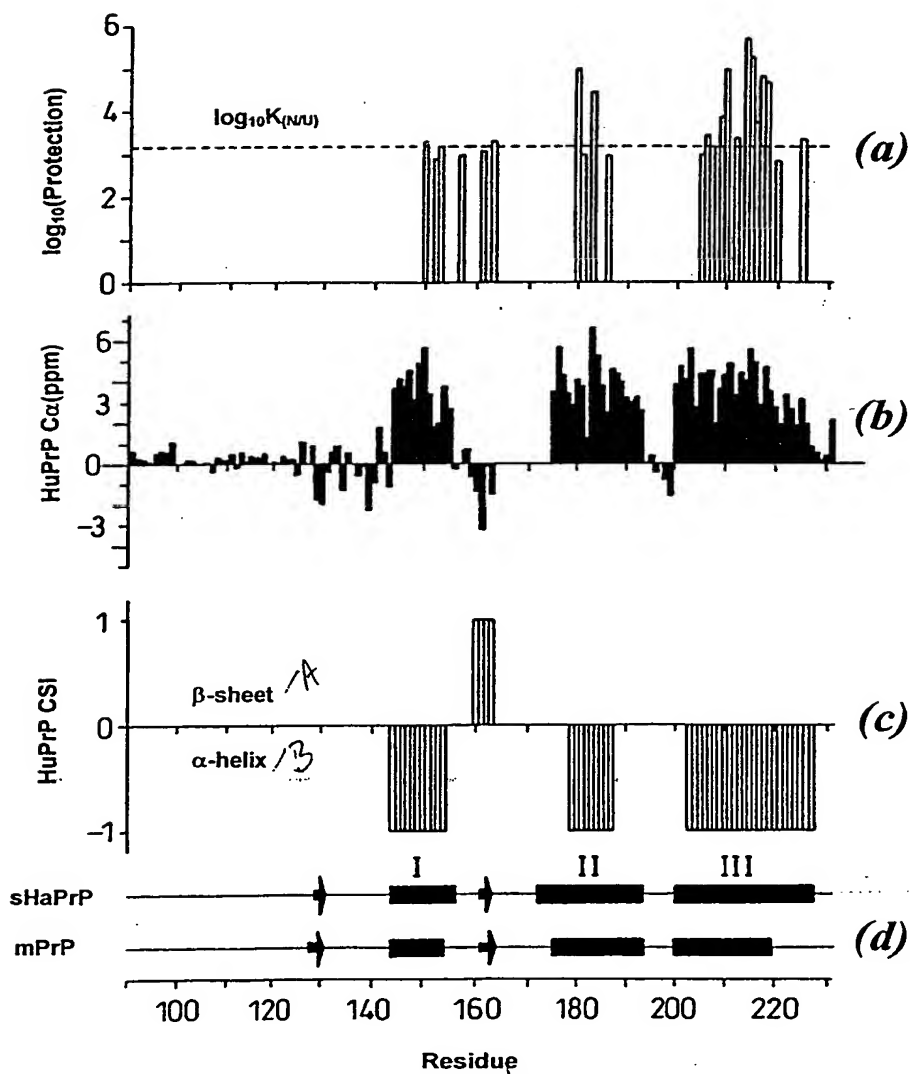
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*Fig. 1*

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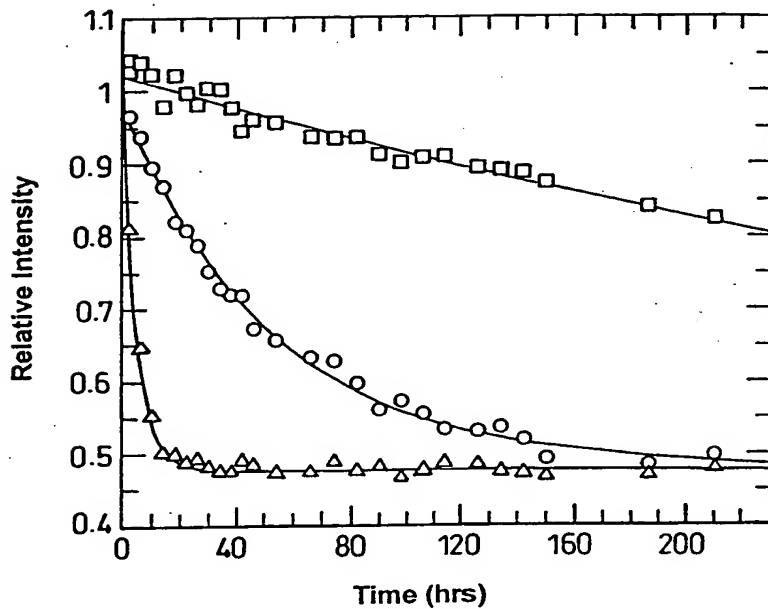
**Fig. 2**

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*Fig. 3*

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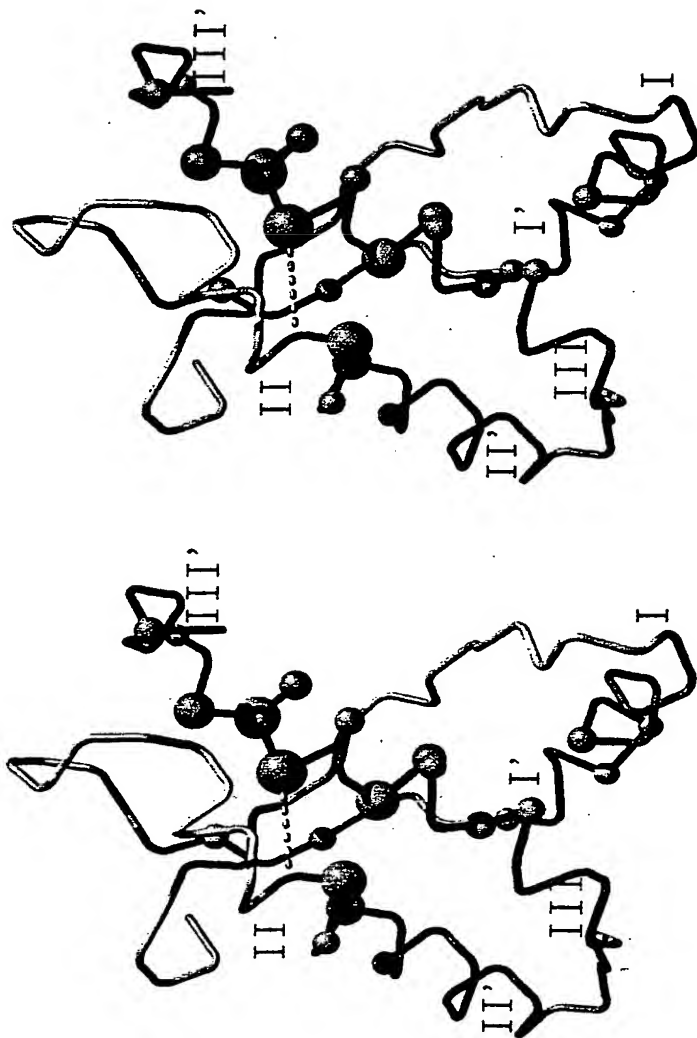


Fig. 4

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**Fig. 5 (Part 1 of 3)**

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Human	MACALAGAVGOLGPGMSHRETIHSGDZEDRIAREHREIPNOVITAPFQINQNVHDCVHATIQTY-TTIGKENTFIDVRKAVVQVQVCTIGIERS--QALY--GSGENVTJSSPP	245
Chimpanzee	.....N.....Q.....S.....	245
Orangutan	.....I.....V.Q.....	245
Gorilla	.....I.....Q.....	245
Monkey (Gz)	.....L.N.....I.....V.Q.....	245
Monkey (S)	.....L.N.....I.....S.....V.....	237
Rhesus	.....L.N.....I.....V.Q.....	232
Gibbon	.....L.N.....I.....Q.S.....	245
Macaque (S)	.....L.N.....I.....V.Q.....	245
Macaque (C)	.....L.N.....I.....V.Q.....	245
Macaque (O)	.....L.N.....I.....V.Q.....	245
Macaque (P)	.....L.N.....I.....V.Q.....	245
Hamadryas	.....L.N.....I.....V.Q.N.....	245
Cercopithec	.....L.N.....I.....V.Q.....	244
Quercus	.....L.N.....I.....V.Q.....	245
Capuchin	.....L.N.....I.....V.Q.....	237
Francolin	.....L.N.....I.....V.Q.....	245
Siamang	.....L.N.....I.....V.Q.....	245
House (RML)	.....V.M.N.M.....I.....V.Q.....	245
House (Sh)	.....M.N.M.....I.....V.Q.....	246
House (Lg)	.....M.N.M.....I.....V.Q.....	246
Sanster (C)	.....ML.N.N.....I.....V.Q.N.....	246
Deu	.....L.N.....I.....V.Q.....	246
Ibex	.....L.N.....I.....V.Q.....	234
Antelope	.....L.N.....I.....V.Q.....	242
Sudu	.....L.N.....I.....V.Q.N.T.....V.....	246
Deer	.....L.N.....I.....V.Q.....	234
Pig	.....L.N.....I.....V.Q.....	246
Polcat	.....L.N.....I.....V.Q.....	247
Dog	.....L.N.....I.....V.Q.....	246
Rabbit	.....L.N.....I.....V.Q.....	246
Arasupial	.....V.NE.....QI.....M.I.Q.S.....	244
Chicken	.....AM.RV.GGSI.D.PD.I.HWS.GA.....R.....DISERT.DV.A.F.....VZISIGPAK.NTSZVAALNGT.VEM.NKV.VT.MCV.Q.NITELA.GIQ.HPADT	245

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Fig. 5 (Part 2 of 3)

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Human	:	VILL-ISFLIFLIVG----	:	260
Chimpanzee	:	.....*----	:	260
Orangutan	:	.....*----	:	260
Gorilla	:	.....*----	:	260
Monkey (Gr)	:	.....*----	:	252
Monkey (S)	:	.....*----	:	267
Rhesus	:	.....*----	:	260
Gibbon	:	.....*----	:	260
Macaque (S)	:	.....*----	:	260
Macaque (C)	:	.....*----	:	260
Macaque (J)	:	.....*----	:	260
Macaque (P)	:	.....*----	:	260
Marmoset	:	.....*----	:	259
Hamadryas	:	.....*----	:	260
Cercopithe	:	.....*----	:	252
Guereza	:	.....*----	:	260
Capuchin	:	.....*----	:	259
Francoisi	:	.....*----	:	260
Siamang	:	.....*----	:	260
Mouse (RML)	:	.....*----	:	261
Mouse (Sh)	:	.....*----	:	261
Mouse (Lg)	:	.....*----	:	261
Hamster (C)	:	.....*----	:	261
Cow	:	.....*----	:	269
Sheep	:	.....*----	:	256
Antelope	:	.....*----	:	261
Kudu	:	.....*----	:	269
Goat	:	.....*----	:	261
Pig	:	.....L.....*----	:	262
Polecat	:	.....L..L.....*----	:	262
Dog	:	.....L..L.....*----	:	261
Rabbit	:	.....*----	:	259
Marsupial	:	.T..FL.....S.----	:	264
Chicken	:	WLA V L L L L . T T . F A M H ---	:	277

*Fig. 5 (Part 3 of 3)*

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